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U. S. DEPARTMENT OF AGRICULTURE.

REPORT
OF
THE ENTOMOLOGIST
FOR
THE YEAR 1889.

AUTHOR'S EDITION.

FROM THE ANNUAL REPORT OF THE DEPARTMENT OF AGRICULTURE
FOR THE YEAR 1889.

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.

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REPORT OF THE ENTOMOLOGIST.

INTRODUCTION.

SIR: I have the honor to present herewith my annual report as Entomologist for the calendar year of 1889. In accordance with your instructions the report has been greatly curtailed as compared with those of previous years. No extensive articles and few of the necessarily scientific details of the work of the Division are included. It is a practical summary of the work, arranged in accordance with your circular of instructions dated November 25, and kept within the thirty-page limit assigned.

BUSINESS OF THE DIVISION.

The sums appropriated for carrying on the work of this Division did not exceed those of last year nor of several previous years. The lump sum of \$20,000 was appropriated for general investigations, and the salaries of the Entomologist and four assistants or clerks were otherwise provided for. From the general appropriation are defrayed the salaries of two special assistants, two clerks, an artist, a messenger, and seven permanent field agents. Three other field assistants have been temporarily employed, and an additional office worker has been upon the rolls for a portion of the year. The remainder of the appropriation has been or will be expended in the payment of traveling expenses, the conducting of experiments and field observations, the purchase of insecticide apparatus and insecticide substances, the employment of occasional field help, the purchase of office apparatus (including cases, boxes for collections, microscopes, breeding cages, the numerous instruments and substances used in the rearing of insects, and in the preparation of permanent collections), as also in the preparation and reproduction of illustrations.

WORK OF THE DIVISION.

As shown in former reports, the time of the office force of the Division, as at present constituted, is largely taken up with routine work, consisting chiefly of correspondence, determination of material sent in for name, care of collections, care of the living insects upon which observations are being made in the vivaria, the making of notes, the preparation of drawings, the reading of proof, and the preparation of the manuscript of the reports and bulletins of the Division; while my own time, in addition, is much occupied, as also that of my first assistant, by calls from persons seeking information concerning injurious insects or desiring instructions of one kind or another, in the ordinary administrative duties, and in directing the

work of special agents. During the past year no less than three thousand seven hundred letters have been written to correspondents in answer to inquiries, while nearly one thousand others have been answered by circulars.

A very large number of additions have been made to the collections, and biologic notes have been made upon two hundred additional species not represented before, each number representing a longer or shorter series of notes with records concerning the different states of the insect and observations made at the office or in the field. The amount of pure museum work done in connection with the National Museum has greatly increased since the organization of the experiment stations under the Hatch bill, and, with the impetus given to applied entomology by the consequent organization of entomological research in so many of the States, this branch of the Division work will necessarily augment. The work of determining material sent in for name is all-important in the benefit it confers, though showing little in results at the Department as compared with the time required. Every year adds to the value of the national collection therefor, and I conceive it to be one of the most important functions of the Division to co-operate with other workers in this as in other directions.

The impetus above referred to has found tangible form in the organization of a National Association of Economic Entomologists, which recently held a very successful meeting at Washington, the proceedings of which are published, by request, in *INSECT LIFE*, Vol. II, No. 6.

The actual publications of the Division during the year have been as follows :

Insect Life :

Volume 1, No. 7, issued January 21 ; No. 8, issued February 21 ; No. 9, issued April 10 ; No. 10, issued April 29 ; No. 11, issued May 27 ; No. 12, issued July 2.

Volume 2, No. 1, issued July 20 ; No. 2, issued August 30 ; No. 3, issued September 21 ; No. 4, issued November 2 ; No. 5, issued December 5.

Bulletin No. 20, "The Root-knot Disease of the Peach, Orange, and other plants in Florida, due to the work of *Anguillula*," by J. C. Neal, Ph. D., M. D., issued Nov. 1.

The Bibliography of the more important writings of American Economic Entomology, Parts 1, 2, and 3: daily expected from the press.

The fifth and final report of the U. S. Entomological Commission, being a report on Forest Insects, by A. S. Packard, is now going through the press.

The work of the agents of the division is summarized at the close of this report, and in accordance with your instructions. The result has been to restrict the account of it to a mere indication or announcement of some of the results obtained, necessarily of little scientific value compared with the more detailed reports.

The chief investigations of the year summed up in this report, are:

(1) The colonization and spread of the imported enemies of the Fluted Scale (*Icerya purchasi*), in California.

(2) Preliminary investigation of the Leaf-mite of the Orange.

(3) An investigation of the habits of, and remedies for, the Horn Fly (*Hæmatobia serrata*).

(4) A partial investigation of the extraordinary outbreak of the Grain Plant Louse (*Siphonophora avenæ*) in several of the Western States.

An investigation was made of an outbreak of the Lesser Migratory Locusts in New Hampshire, in the same locality as that treated of in

my report for 1883. The result of this investigation was published in full in the September number of *INSECT LIFE*.

Considerable attention has also been given to perfecting the records of appearance of Brood VIII of the periodical Cicada, which appeared during the year, and more accurate limitations of the territory occupied by it have resulted.

The occurrence of the Buffalo Gnat in great numbers in Louisiana under peculiar circumstances seemed to warrant the sending of an agent to particularly investigate the subject; and his report which has already been published, (*INSECT LIFE*, Vol. II, No. 1, July, 1889), showed conclusively that the abundance of the gnats in the locality in question was caused by Government operations in diverting a large raft of logs of several acres in extent into Bayou Pierre, a tributary of the Red River, thus furnishing extensive breeding grounds for the gnats.

The work of the Division in investigating the Hop Phorodon, which has been in progress for several years, was completed most satisfactorily early in the present year. A preliminary report was made in my report for 1888.

The mission to Australia has been fraught with such remarkably satisfactory results that I take this occasion to publicly express my acknowledgments to two persons who were most prominent in contributing to its success. A number have thus contributed; but first, Mr. McCoppin, commissioner to the Melbourne Exposition, deserves particular thanks not only for the promptness with which he seconded the suggestion of co-operation, without which the State Department would scarcely have acted, but also for the uniform kindness with which he received and the aid which he gave to the agents of the Division sent out to him. Secondly, all honor is due to Mr. Koebele, on whom the greatest responsibility fell, and whose devotion to the object in view, indefatigable effort, and loyal carrying out of instructions brought success where others would have failed. The success of this experiment has naturally increased the interest in this mode of dealing with injurious insects, and while the circumstances in this case were in some respects peculiar, yet the cases are numerous where similar work will be productive of similar good. I have also desired to return to the Australian fruit-growers the kindness they have shown in helping us, by doing them, if possible, a like service; and hope to send over in the course of time some of the parasites of the Codling moth, some additional species to those already known having been discovered by Mr. Koebele in California the present year.

The work for the immediate future, as partially planned, includes the publication of a number of bulletins already wholly or partly prepared; the completion of the investigation of the Leaf-mite of the Orange; the completion and publication of the report on insecticide machinery; the completion and publication of reports upon the insect enemies of live-stock; the insect enemies of grain and grasses; the final part of the bibliography of economic entomology, etc.

In the Silk Section of the Division the experiments in automatic silk-reeling have been continued in the lines indicated in former reports. Mr. Philip Walker was sent to Europe to fully and carefully study the whole subject of silk culture, especially as it bears upon our own efforts and with a view of ascertaining what progress and improvements have been made abroad.

While in France I also paid particular attention to the question of automatic reeling. Inasmuch as my observations abroad and the

work of the past year have furnished no grounds for changing the opinions clearly expressed by me in my last annual report on this subject, and inasmuch, moreover, as, for that reason, you have concluded to leave to others the future conduct of the silk experiments, relieving me of any further responsibility therefor, I abstain from any reference to the subject in the present report.

Much of my time and thought have been given during the year to the exhibit of our agricultural products at the Paris Exposition. The success thereof has already been announced by you in a notice sent to the press with a list of awards, and it suffices here to add that since that statement I have received a supplementary list, so that the agricultural exhibit, included in fifteen classes, received seven grand prizes, forty gold, sixty-eight silver, and fifty-four bronze medals, and thirty-nine honorable mentions. This is a larger relative percentage of medals than was awarded to the United States in the other seventy-one classes and a very much larger percentage of awards in the agricultural groups as compared with those obtained by the United States either at the Paris Exposition of 1867 or of 1878. In the special class of "Beneficial and Injurious Insects" only three grand prizes were awarded in all, two of which were to the United States and one to Japan.

The Divisional force remains essentially the same as it was a year ago, and while each and all deserve my thanks for the manner in which they have performed their several duties, I feel that I shall not be invidious in specially expressing my acknowledgment to my first assistant, Mr. Howard, who, owing to my long absence in Paris, has had more than the usual responsibility.

Respectfully submitted, December 31st, 1889.

C. V. RILEY,
Entomologist.

Hon. J. M. RUSK,
Secretary of Agriculture.

THE FLUTED SCALE.

(*Icerya purchasi* Maskell.)

Order HOMOPTERA; family COCCIDÆ.

[Plate III.]

In our last annual report we gave an account of all recent observations upon this insect and brought the investigation down to January, 1889. Few additional points have been learned the present year, and the great practical success of the importation of the Australian insect enemies of the Scale has so relieved the minds of the citrus growers of the Pacific coast that little attention has been paid by them to the subject of washes and gas treatment. In fact the Fluted or White Scale is practically no longer a factor to be considered in the cultivation of oranges and lemons in California. The history of the introduction of this pest; its spread for upward of twenty years, and the discouragement which resulted; the numerous experiments which were made to overcome the insect, and its final reduction to unimportant numbers by means of an apparently insignificant

little beetle imported for the purpose from Australia, will always remain one of the most interesting stories in the records of practical entomology.

We may hardly hope, however, that the last chapter in the story is written. On the contrary, it is more than probable, and in fact we strongly anticipate, that the *Icerya* will partially recuperate; that the *Vedalia* will, after its first victorious spread, gradually decrease for lack of food, and that the remnants of the Fluted Scale will in the interim multiply and spread again. This contest between the plant-feeder and its deadliest enemy will go on with alternate fluctuations in the supremacy of either, varying from year to year according to locality or conditions; but there is no reason to doubt that the *Vedalia* will continue substantially victorious, and that the power for serious harm, such as the *Icerya* has done in the past, has been forever destroyed. We have learned, also, that it will always be easy to secure new colonizations of the *Vedalia* where such may prove necessary, or even new importations should these become desirable.

We shall give in this connection simply a summary of the closing phases of the interesting experiment, with such other facts as are worthy of being placed upon record.

IMPORTATION OF THE AUSTRALIAN INSECT ENEMIES.

In our report for 1888 we showed how Mr. Koebele was sent to Australia in August and gave an account of his early sendings of insect enemies, recording how his first shipment arrived in excellent condition and containing a very large number of healthy living specimens of the Dipterous parasite which at that time was known by the name of *Lestophonus iceryæ*, together with ladybirds and lace-wing flies. We also showed how the ladybird larvæ attacked the first *Iceryas* which they met upon being liberated from the packages. The next shipment, as we there indicated, was not so successful, some of the boxes having been smashed by the falling of ice in the ice-house on the steamer, and the contents of others molding. In January another small lot containing fifty *Lestophoni* and forty-eight *Vedalias* together with a few other insects was received. It was in the December shipment that a secondary parasite of the *Lestophonus* was found. Late in February Mr. Koebele left Australia and spent a large part of the month of March in New Zealand, pursuing there the same quest. Before leaving Australia he sent another quantity of *Lestophonus* and a large number of Ladybirds of four different species, all of which were alive upon arrival in Los Angeles. The Ladybirds made themselves perfectly at home and began at once to feed upon *Icerya*. In New Zealand he was unable to find any true parasites, with the possible exception of a single small two-winged fly, but he collected a large number of Ladybirds, among them the same species of *Vedalia* which he had previously found in Australia. Many of these were brought with him on his return to California in April.

The parasites had been received in California by Mr. Coquillett, and after the disastrous second shipment, which was further delayed in the custom-house in San Francisco, the Secretary of the Treasury, at our request, kindly issued an order to the collector of the port to allow the subsequent packages entry free of duty and to forward them at once to Mr. Coquillett. The manner in which Mr. Coquillett disposed of the *Lestophonus* was mentioned in our last report,

and we there figured on Plate VIII the tent under which he endeavored to colonize them. Concerning his experience with the *Vedalia* and the details of its early distribution we have given an account in No. 3, Vol. II, *INSECT LIFE*, and as this bulletin reaches but a small share of the readers of this annual report we may briefly state that as fast as the ladybirds were received they were placed under a tent on an *Icerya*-infested orange tree at Los Angeles. Here they were allowed to breed unmolested, and early in April it was found that nearly all of the *Iceryas* on the tree had been destroyed. Accordingly, one side of the tent was removed and the Ladybirds were allowed to spread to the adjoining trees. At this time Mr. Coquillett began sending out colonies to various parts of the State with the assistance of Mr. J. W. Wolfskill and Mr. Alex. Craw, and by the 12th of June ten thousand five hundred and fifty-five specimens had been distributed to two hundred and eight different orchardists. This was the course taken with the first three consignments, one hundred and twenty-nine specimens in all. The last two consignments, numbering one hundred and eighty-five, were colonized in the groves of Col. J. R. Dobbins, in San Gabriel, and Messrs. A. B. and A. Scott Chapman, in the San Gabriel Valley; Mr. Dobbins receiving eighty-five and the Chapmans one hundred. Mr. Coquillett, writing in August last, said of the distributions made by himself, Mr. Wolfskill, and Mr. Craw from the Los Angeles colony, that in nearly every instance of the two hundred and eight the colonizing of the ladybirds on infested trees in the open air proved successful. The orange and other trees, about seventy-five in number, and also the shrubs and plants growing in Mr. Wolfskill's yard, had been practically cleared of *Icerya* by the ladybirds, and the latter had of their own accord spread to the adjoining trees for a distance of three-quarters of a mile from the original tree. That, as we have said, was in August.

Concerning the later colonizations, Colonel Dobbins and the Messrs. Chapman have themselves reported. Colonel Dobbins, writing as early as July 2, made use of the following language:

The *Vedalia* has multiplied in numbers and spread so rapidly that every one of my thirty-two hundred orchard trees is literally swarming with them. All of my ornamental trees, shrubs, and vines which were infested with White Scale are practically cleansed by this wonderful parasite. About one month since I made a public statement that my orchard would be free from "*Icerya* by November 1," but the work has gone on with such amazing speed and thoroughness that I am to-day confident that the pest will have been exterminated from my trees by the middle of August. People are coming here daily, and by placing infested branches upon the ground beneath my trees for two hours can secure colonies of thousands of the *Vedalia*, which are there in countless numbers seeking food. Over fifty thousand have been taken away to other orchards during the present week, and there are millions still remaining, and I have distributed a total of sixty-three thousand since June 1. I have a list of one hundred and thirty names of persons who have taken the colonies, and as they have been placed in orchards extending from South Pasadena to Azusa, over a belt of country 10 miles long and 6 or 7 in width, I feel positive from my own experience that the entire valley will be practically free from *Icerya* before the advent of the new year. You will be as much pleased to read this as I am to write it.

October 22, Colonel Dobbins wrote further as follows:

* * * The *Vedalia* had practically freed my orchard of *Iceryas* on the 31st of July. It was on that date that I was obliged to post a notice at the entrance to my place saying that I had no more *Vedalias* for distribution. The Scale and Ladybird had fought out the battle, and while the carcasses of the vanquished were everywhere present to tell of the slaughter, the victors had disappeared almost entirely from the field. I have 35 acres in orchard—some three thousand two hundred trees in all. I never colonized any *Vedalias* in my grove, excepting the two consign-

ments which you brought to me yourself—one box on February 22 and two boxes March 20. I noticed the first increase from lot No. 1 on the 15th of April, and from lot No. 2 on the 24th of the same month. On the 25th of April I found larvæ upon several adjacent trees. These facts are from memoranda made at the time. I have a list of the names of fruit-growers, two hundred and twenty-six in number, to whom I personally distributed over one hundred and twenty thousand *Vedalias* in colonies of various sizes between May 31 and July 31.

Mr. A. Scott Chapman describes the result of the colonization upon his own place and that of his father in a letter dated October 18th, as follows:

* * * The *Vedalias* that you brought to my place about the 20th of last March, and which we colonized on four large orange trees that were covered with Fluted Scale, have spread in all directions, although, to begin with, they followed the direction of the wind most readily. From those four trees they have multiplied so rapidly that in my orchard of three thousand trees it is seldom that we can now find a Fluted Scale. I find a few of them on some weeds in spots, but I can also find the beetles there. The trees have put on a new growth and look altogether different; even the black fungus on the old leaves has loosened its hold and begins to fall to the ground. Besides having cleaned my orchard they spread also to the orchard of my cousin and to my father's orchard; the latter was also re-enforced by colonies from Mr. J. W. Wolfskill and from Col. J. R. Dobbins. As my father has some ten thousand trees, and most all were more or less infested, the *Vedalias* had a grand feast ahead of them, and they have done their work most wonderfully. What I have said of my orchard applies to my father's also, and really to all our neighbors. When the *Vedalias* first began to multiply we took colonies of fifty or more in the pupa state and placed them in different portions of the orchard, and even had we not done so the *Vedalia* unaided would itself have reached there in almost the same time.

On the Chapman place the *Vedalias* have cleaned the Fluted Scales off of the 150 acres of land. They have taken more than an oppressive burden off of the orange-grower's hands, and I for one very much thank the Division of Entomology for the *Vedalia cardinalis*, the insect that has worked a miracle.

In August Prof. W. A. Henry, director of the Wisconsin Agricultural Experiment Station, visited California in the interest of the Department of Agriculture and made personal observations upon the result of this importation of the *Vedalia*. His account we quote in brief

In studying this insect we first visited the place of Mr. William Niles, in Los Angeles, where the "Ladybird" (*Vedalia cardinalis*) was being propagated by the county insect commission for dissemination among the orange groves infested with the Cottony Cushion, or White Scale. We found five orange trees, standing about 18 feet high, inclosed by walls of cheap muslin supported by a light frame-work of wood. The orange trees inside this canvas covering had originally been covered with the White Scale, but the *Vedalia* which had been placed on these trees were rapidly consuming the last of the pests. Entering one of these canvas houses we found the *Vedalia*, both larvæ and adults, busy consuming the Scale; here and there on the canvas were the beetles endeavoring to escape to other trees. These insectaries were in charge of Mr. Kircheval, one of the county insect commissioners, who kept a record of the distribution of the beetle. It was indeed a most interesting sight to see the people come—singly and in groups—with pill boxes, spool-cotton boxes, or some sort of receptacle, in which to place the *Vedalias*. On application they were allowed within the insectaries, and each was permitted to help himself to the beetles, which were placed in the boxes and carried away to be placed on trees and vines infested with the White Scale at their homes. Mr. Kircheval kept a record of the parties and the number of beetles carried off. The number coming for the *Vedalia* was surprisingly large—scores in a day—and each secured at least a few of the helpful beetles. That the supply should hold out under such a drain was a great surprise, and speaks better than words of the rapidity with which the *Vedalia* multiplies when there are Scale insects enough to nurture the young.

We visited other points—Lamanda Park, Santa Anita, Sierra Madre Villa, Pasadena, etc. At the time of our visit to Sierra Madre Villa, August 23, the White Scale had already disappeared before the *Vedalia*. At Santa Anita, the ranch of Mr. E. J. Baldwin, we examined a 350-acre orange orchard, in which the White Scale had started a most destructive course. Mr. Baldwin began an equally vigor-

ous defense, going personally into the orchard and superintending the work of fighting the White Scale. There was every sign, however, that the Scale was going to be the victor. Some of the trees were almost ruined by the severity of the application made. Happily, before the pest had gone far in its work, the Vedalia was heard from, and Mr. Baldwin secured a number, which were placed in the hands of one man specially detailed to look after its welfare. This individual spent six weeks in colonizing the Vedalia in various parts of the orchard. After that time a careful examination showed the superintendent that the work of colonizing was so complete that further effort in that line was unprofitable. It was predicted at the time of our visit that a few weeks more would leave the orchard entirely free from the White Scale. At Chapman's we found the citrus orchard, formerly so famous, entering the death stages from the White Scale, which was now fortunately being so effectually checked. At Pasadena, on the grounds of Prof. Ezra Carr, we found that some of the shrubbery had been seriously injured by the White Scale, but thanks to the Vedalia not a single pest was alive at the time of our visit. Mrs. Jennie Carr pronounced the Vedalia "a miracle in entomology."

A word in relation to the grand work of the Department in the introduction of this one predaceous insect. Without doubt it is the best stroke ever made by the Agricultural Department at Washington. Doubtless other efforts have been productive of greater good, but they were of such character that the people could not clearly see and appreciate the benefits, so that the Department did not receive the credit it deserved. Here is the finest illustration possible of the value of the Department to give people aid in time of distress. And the distress was very great indeed. Of all scale pests the White Scale seems the most difficult to cope with, and had no remedy been found it would probably have destroyed the citrus industry of the State, for its spreading to every grove would probably be only a matter of time. It was the Department of Agriculture at Washington which introduced the Washington Navel Orange into South California, and the Department has now given an effective remedy for the worst scale insect. The people will not soon forget these beneficial acts.

We have quoted these statements of Colonel Dobbins, Mr. Chapman, and Professor Henry for the reason that they are made by eye-witnesses both interested and uninterested and afford a more perfect idea of the good accomplished than anything we can say. The rapidity with which the Vedalia has multiplied and the voracity which it has shown have cast nearly into the shade the other insect enemies brought over at the same time. The Dipterous parasite, of which we expected much, proves to be a very slow breeder and not to adapt itself readily to the California surroundings. The same may be said of the other insects brought over alive. A very promising predaceous caterpillar (larva of *Thalpochares cocciphaga* Meyrick, Plate III, Fig. 6) was unfortunately lost, partly through the very success of the Vedalia. Several of the other ladybirds, nearly all of the Scymnid group, were observed to feed, but were soon lost sight of. They may possibly increase and yet be found acclimated.

ADDITIONAL POINTS BROUGHT OUT THIS SEASON.

We may briefly summarize a few other matters connected with Ice-rya.

Gas Treatment.—We mentioned in our last annual report a patent scheme for one of the fumigating processes, and stated that from information which we had received from the Patent Office no patent had been issued and that on account of the so-called Hatch patent having expired no letters patent can be issued for the process. Another claim to a patent has recently been made in California and in reference to it we need only repeat our statement of a year ago. As indicated in this report under the head of "Work of field agents," Mr. Coquillett has been experimenting with a view of finding a cheaper method of using the hydrocyanic gas. He has succeeded in reducing the expense to one-third that necessitated by the former

method, while much of the cumbersome machinery described in our report for 1887 has been found unnecessary.

Native Parasites.—Of the native parasites mentioned in our last report, three, namely, *Encyrtus dubius*, *Coccophagus californicus*, and *Thoron opacus* were described by Mr. Howard in the February number of INSECT LIFE. The others we hope soon to describe under the names already given. A new enemy has been recorded by Mr. Coquillett in the August (1889) number of INSECT LIFE, page 49, in the shape of a long, slender, brownish soldier beetle, *Telephorus consors*, which feeds upon the eggs of *Icerya* after first tearing off the cottony covering.

Mr. Webster's Trip to Australia.—Our Indiana agent, Mr. F. M. Webster, went to Australia on the December (1888) steamer, returning to this country in April. We sent him primarily to make a report on the agricultural aspects of the Melbourne Exposition, in accordance with our arrangement with the State Department, but he also assisted Mr. Koebele somewhat in his work. A report by Mr. Webster upon some Tasmanian insects may be found in the June number of INSECT LIFE, pages 361 to 364.

An Application to prevent Icerya from ascending Trees.—Mr. Coquillett reported in April that he had been experimenting in this line, and found that an application prepared of 4 ounces of resin, 1 ounce of beeswax, and 5 fluid ounces of cotton-seed oil melted and stirred together and spread upon the trunk of the tree will remain moist for over a week. He advises the use of this application where the trees have been washed with cold water, as a means of preventing the scale insects from climbing back upon the same tree.

Further Importations.—From the present outlook no further importation of *Vedalia* will be necessary. In May the fruit-growers of California petitioned the Department to send another qualified agent, and the entire matter is well summarized in a letter written by the Hon. Edwin Willits, Assistant Secretary of Agriculture, to the Hon. Ellwood Cooper, president of the State board of horticulture, and which is published in the July number of INSECT LIFE. The letter details the exact position in which the Department is placed. The Department has now correspondents in Australia so well qualified and so extremely obliging that it is quite likely that future invoices may be received without the necessity of sending an agent to that country.

New Food-plant of Icerya.—Mr. Coquillett wrote in May that he had for the first time found the *Icerya* to infest a conifer. A Cedar of Lebanon (*Cedrus libani*) growing in a door-yard in Los Angeles was found covered with the insect in all stages. This is the first record of its infesting a conifer in California, although in New Zealand it has been found upon pines, firs, and spruce.

A Florida Icerya Scare.—The Florida newspapers on a number of different occasions during the early part of the season published statements to the effect that the *Icerya* had been found in Florida. A number of these cases were investigated by correspondence and either the common Mealy Bug or the Florida Wax-scale was found in every case to have originated the rumor. *Icerya purchasi* has not been found in any of the Eastern States, although its appearance on the Atlantic coast is possible at any moment. We pointed out the danger, in our report for 1886 and in other writings, and Florida orange-growers should adopt concerted means to prevent such a misfortune by the most stringent examination and disinfection of

plants and cuttings from southern California, Australia, New Zealand and South Africa.

Concerning the Lestophonus.—The genus which Dr. Williston erected for the first found of the Australian natural enemies of *Icerya* proves to be a synonym, and the insect should be known as *Cryptochetum icerye* (Williston). After an examination of the material in the Department collection made by Dr. Williston during April last, he was tolerably certain that the specimens of this parasite reared from *Icerya* were identical with specimens reared from another large scale insect in Australia named *Monophloeus crawfordi*, and his statement to this effect is published in the May number of *INSECT LIFE*. His conclusions have been criticised by Mr. F. A. A. Skuse, of Australia, and recent examinations which we have made with more extended material prove that Mr. Skuse is correct and that the species infesting *Monophloeus* is a different species, as species go, from that infesting *Icerya*. Both species, however, seem to breed indiscriminately upon both *Icerya* and *Monophloeus*, so that Mr. Koebele's sendings of infested *Monophloeus* were as valuable as anticipated.

The Vedalia confined for Food to Icerya.—The feeding habits of the *Vedalia* seem to be very uniform, and up to the present time it has not been noticed to feed upon any other scale insect than the one for whose destruction it was brought over. We at one time feared that it might breed upon the Cochineal insect, in which case its spread into Mexico might have proved unwelcome; but we learn from Mr. R. Allan Wight, of New Zealand, that in that colony the *Vedalia* does not feed upon *Coccus cacti*.

A new primary Hymenopterous Parasite in Australia.—Just as we are sending in this report we have received from Mr. Crawford a series of a new primary parasite which he reared from a number of *Iceryas* received from a place 50 miles south of Adelaide. Mr. Crawford writes us that the proprietor of the grove had never seen anything of the kind and sent them to him for determination. Upon examination they prove to belong to a new genus somewhat closely allied to *Dilophogaster* Howard, the only species of which is a very valuable parasite of the Black Scale in California. This new genus we have called *Ophelosia*, naming the species after Mr. Crawford, in testimony of his great interest in the matter and of our high appreciation of his labors. (See *INSECT LIFE*, Vol. II, Nos. 7 and 8, p. 248.)

THE SIX-SPOTTED MITE OF THE ORANGE.

(*Tetranychus 6-maculatus* Riley.)

Order ACARINA; family TETRANYCHIDÆ.

[Plate II.]

Since 1886 no pest has caused more uneasiness and alarm among the orange-growers of Florida than the one now generally known by the above name. Our correspondents have also referred to it, however, as the "Leaf-mite," the "Spider," the "California Spider," the "Red-spotted Mite," and the "Red Spider." This pest first made its appearance in numbers in 1886, being especially abundant at that

time in groves at Maitland and Orlando. Its appearance immediately after the severe freeze of 1885-'86 led to the very general belief, which is probably well founded, that the trees, weakened by the cold of that winter, were unable to resist or sustain the attacks of the mites, thus enabling the latter to multiply prodigiously.

We are at present unable to decide whether this mite is an indigenous species or a comparatively recent introduction. The former supposition seems, from the facts at hand, the more probable.

Whatever its origin, its appearance in injurious numbers practically dates from the spring of 1886. With the rainy season, June and July, of that year, the mites entirely disappeared. They again appeared during the dry season, March to June, 1887, in even greater numbers and over a wider territory, extending their attacks over almost the entire orange belt of the State. The drought of that year was unusually severe and the mites increased enormously, but were again destroyed by the midsummer rains. During the year 1888 its appearance was not so marked, but it was very generally reported, and in many places was as injurious as in either of the two preceding years.

The long and severe drought of the present year, during which in many places seven weeks passed without rain, again afforded the best possible conditions for the abundant increase of the mite, and there is no doubt but that it was more wide-spread and destructive than in former years.

Since the appearance of the Six-spotted Mite of the Orange in 1886, the Florida press has made frequent reference to it, both editorially and through correspondence. Several of the articles, and especially those of a former agent of the Division, Mr. H. G. Hubbard, of Crescent City, Fla., were of a practical nature, describing the work of the mite, and giving measures of value against it.*

During the past four years the Division has received, especially during the months of April, May, and June, a large number of letters inquiring about this pest, all of which have been answered at length, giving both the history of the mite and the best means against it.

On its re-appearance in the spring of 1889 the Department was again urged by orange-growers, and particularly by Senator Pasco, to send an agent to Florida to study its habits and to experiment with remedies. At that time, however, we were unable to carry out the suggestion, and it was determined to draw up a preliminary report, and at some future time, if found desirable, to make a fuller field study of the subject. Letters were therefore sent out to a large number of orange-growers of Florida, in which the full history and habits of the mite were given as far as known, and also the various measures against it that had been used or recommended. Request was made that these remedies or others be tested, and also that we be informed of any new facts relating to the habits or remedies that might come under notice.

The responses have been very satisfactory and have been used in the preparation of this article. Mr. Ashmead, an agent of the Division, was in Florida in July, and was directed to make investigations relating principally to the disappearance of the mites with the rainy season.

* See articles by Mr. Hubbard in the *Florida Dispatch*, May 14, 1886, and July 25, 1887, and by Mrs. L. B. Robinson, in *The Home and Farm*, July 15, 1886.

FOOD-PLANTS.

The original food-plant of this mite is still uncertain. It was first noticed on the Wild or Sour Orange. It soon attacked the Sweet Orange, and the damage was much greater than in the case of the wild trees. Later the lemon and citrus trees generally were infested.

DESCRIPTION AND LIFE HISTORY.

The natural position of this mite is with the Spinning Mites (*Tetranychidae*), of which the Red Spider (*T. telarius*) of hot-houses is a familiar example. These mites have the habit of congregating on the leaves of various plants, especially on the lower side along the principal veins, where they spin their delicate, scarcely perceptible, webs. Under the protection of these webs they feed on the juices of the leaf extracted through abrasions in the epidermis, causing the leaves to become pale and spotted, and finally to shrivel and fall.

The species under consideration when full-grown is about 0.3 millimeter long, oval in shape, being widest just back of the eyes. The general color is pale greenish-yellow; the abdomen is marked above with six or less small dusky spots, which are arranged in two subdorsal rows of three spots each. These markings are quite constant, especially in the smaller and more numerous specimens, though somewhat variable in the larger mites.

The young mite differs from the adult in size, and in being either without markings or in having the middle pair wanting; also in having but three pairs of feet.

The eggs, which are loosely attached to the web, are globular, very minute, but large in proportion to the size of the adult mite, and are either colorless or very pale greenish-yellow.

With warm and dry weather the period from the egg to the adult is certainly short, probably not exceeding ten days.

MEANS OF DISPERSION.

This mite may be carried from tree to tree or from grove to grove as are the scale pests of the Orange or the rust mites, the various means of dispersion of which are discussed at length in Hubbard's "Insects Affecting the Orange." They are doubtless transported on leaves, fruit, and nursery stock; and more commonly, perhaps, by attaching themselves to birds and insects. The rate of progression of the mites is about 2 inches to the minute or 10 feet to the hour, a speed sufficient to enable them, unaided, to overrun a grove in a single season.

EFFECT OF ITS ATTACK.

The first indication of the work of this mite is the yellowing of the leaves, which on the upper surface shows as a line of streaks and spots along either side of the midrib (Plate II, Fig. 2). The under surface (Plate II, Fig. 1) becomes soiled by the accumulated excrements in the form of minute black spots and by the webs and cast skins of the mites. Later the leaves curl or shrivel and finally fall, leaving the tree nearly bare, and in severe cases the limbs are killed back several inches. The general estimate of our correspondents is that badly infested trees lose one-half or more of their leaves,

and from one-third to two-thirds of the half-grown fruit. The falling, especially of the latter, is also charged to the drought. A single instance of the shrinkage in the yield of oranges from this cause may be given. Mr. A. S. Kells, manager of the Crescent Orange Grove Company, of Citra, Fla., writes June 10, 1889:

From this grove we shipped 24,000 boxes of oranges during the past season, whereas this season we only expect about 9,000 or 10,000 boxes, although the trees were never so laden with bloom as in the spring of 1889.

TIME OF APPEARANCE; EFFECTS OF CLIMATE AND SOIL.

The yearly injuries occasioned by the mites, and hence the mites themselves, begin to be noticed in the latter part of February or first of March, and the severity and duration of their attacks are dependent on the dry season, which prevails to a greater or less degree from February or March to the middle of May or the first of June. The rainy season of four to six weeks' duration in June and July so reduces their numbers that they escape the further notice of the orange-growers, who very generally report that they entirely disappear. We have reports, however, from one or two intelligent observers of the occurrence of both eggs and mites on the trees in August and September. That the disappearance of the mites is almost complete is still further shown by the investigation of Mr. Ashmead already alluded to. After examining in July a number of groves that had been severely infested earlier in the season, he was able to find living mites in but one instance, and then only in limited numbers. We have little direct evidence, therefore, that the mites breed on the orange trees from July to February, but until evidence to the contrary is produced it is safe to assume that some few survive the rains, and by reason of their limited numbers and the new and vigorous growth of foliage following the rains they do no appreciable damage and are not noticed.

Rapid increase is prevented from July to September by frequent showers, and from October to February by rains and cold. The latter period may either be passed by the adult in a dormant condition under bark or other protection near at hand, or by the eggs, as is the case with certain allied species the habits of which are known.

It has been abundantly proved that vigorous trees are comparatively free from the attacks of the mites. This is shown in that serious injury is only done in the time of drought; that young growing trees are little affected; that the hardy Wild Orange is much less subject to attacks than the sweet varieties; and that trees grown on low moist land, or where irrigation or artificial watering is practiced, are likewise exempt.

Trees grown on "high hammock land," which is rich in the elements of plant food, are not injured to any extent. The "pine or sandy land," on which ninety-nine one-hundredths of the oranges are grown, and on which artificial fertilizers must be constantly employed, suffer most both from the drought and the mite.

EFFECT OF CLEAN AND CAREFUL CULTURE.

Mr. Charles F. Parker, of Gabriella, Orange County, writes that by clean culture he was able to keep his grove comparatively free

from the mites and to secure large yields of fruit. In this connection he says, in letter of December 30, 1887:

I did what I thought common sense suggested, viz, at once set about cow-penning* and well working that portion of the grove. * * * The result, whether of the treatment or of natural causes, was that this year (1887) these trees have all borne heavily, and I have seen scarcely one of the pests in any part of the grove of one thousand trees.

Mr. Andrew Hamman, of Fort Mason, Lake County, in letter of June 13, 1889, states that the grove of which he has charge, Mr. J. M. Bryan's, suffered less than one-fourth as much from the mite and drought as others in the neighborhood, because, as he writes, it was kept thoroughly cultivated and clean.

REMEDIES.

The fact that the midsummer rains effectually destroy the mites has led to a very general neglect of measures that could be used with good results earlier in the season, and orange-growers as a rule have relied on the possibility of timely rains instead of instituting energetic and preventive work against this pest. A number of trials with insecticides have been made, however, and the following accounts have been received, for the most part in answer to our request for such reports, already referred to. Others have appeared in Florida papers. Both in the case of the letters and the published accounts, we have quoted the language of the writers.

The principal insecticides employed have been the kerosene emulsions, to which powdered sulphur has commonly been added, whale-oil soap and sulphur, and the Eureka Insecticide, a preparation of sulphur and lime intended especially for the Orange Rust-mite, manufactured by E. Bean, Jacksonville, Fla. All the insecticides named have given fairly good satisfaction. The use of whale-oil soap and sulphur is recorded in experiments Nos. 1 and 2; of kerosene emulsion and sulphur in Nos. 3 to 6; of the Bean Insecticide in No. 7. Applications of pure water have been followed with good results, as shown in experiments 8 and 9.

It is worthy of note that sulphur, the well-known specific against the Orange Rust-mite is also a valuable means against the Six-spotted Mite of the Orange, so that the same application that prevents the rusting of the orange by the former mite will keep the latter in check.

EXPERIMENTS WITH INSECTICIDES.

No. 1.—*Whale-oil Soap and Sulphur*.—"The remedy is sulphur, which is best applied with some viscid liquid in the form of spray. Whale-oil soap solution is an excellent medium in which to apply the sulphur, as it is itself a powerful insecticide, and moreover causes the sulphur contained in the solution to adhere to the leaves. The eggs of the mite are not killed by the mixture, but the sulphur remaining on the leaves will kill the mites as they hatch. The whale-oil soap solution should not be less than one-quarter of a pound of soap to 1 gallon of water. One pound of sulphur will suffice for 5 gallons of the liquid."—(H.G. Hubbard, in *Florida Dispatch*, July 25, 1887.)

No. 2.—"The most effective wash I have known to be tried here is a mixture of whale-oil soap, 7 pounds, and 1 quart of sulphur by measure to 1 barrel of 40 gallons of water.

"This applied in a fine spray destroys all the living mites and leaves a deposit of sulphur on the leaves, which destroys the young mites as they hatch."—(A. S. Kells, Citra, Marion County, Fla., June 11, 1889.)

No. 3.—*Kerosene Emulsion and Sulphur*.—"Kerosene emulsion, with 2 or 3 ounces of dry sulphur added to each gallon of the wash, may be used as a remedy. A strong solution of whale-oil soap with sulphur will also be effective. Sulphurated lime,

* Fencing groves and feeding cattle in them.

made by boiling together one part of sulphur, two parts of lime, and ten parts water, will undoubtedly kill the mites, but will not be likely to destroy the eggs. Whatever remedy is used, two or three applications will be needed, owing to the impossibility of exterminating the eggs. The applications should be made at intervals not exceeding one week: five days will be safer if the weather is warm."—(H. G. Hubbard, *Florida Dispatch*, May 17, 1886.)

No. 4.—“Used Hubbard’s kerosene emulsion with addition of 3 ounces of sulphur to each gallon of the mixture, applying with a small hand-pump. Pump was so small that I could not do much, but I am satisfied that the mixture killed the mites whenever it came in contact with them. Had no glass with which to observe the effect on the eggs, and in a few days the mites were back again, whether from eggs or from other trees I could not be sure, and I am satisfied that had they all been killed on any tree they would soon have returned from other trees.”—(Charles G. Wilson, *Rose Hill, Fla.*, June 10, 1889.)

No. 5.—“I used (1886) the kerosene and whale-oil soap emulsion, with the result that it diminished their numbers, although it did not exterminate the pest.”—(Charles F. Parker, Gabriella, Orange County, *Fla.*, June 10, 1889.)

No. 6.—“While upon this subject it may interest you to know that I followed your instructions, spraying the trees with kerosene and whale-oil emulsion, always near sundown, and doing this thoroughly. Only partial success.”—(Charles F. Parker, December 30, 1887.)

No. 7.—*Bean’s Eureka Insecticide*.—“Last year we sprayed our trees for the rust-mite with Mr. Bean’s preparation of lime and sulphur. We have been over the grove once this year and now again, and can see that we are helping the trees; but it is very hard to kill all the insects. We expect to continue going over the trees, and thus keep the fruit bright, as well as get rid of the spider. By means of a horse-cart, the driver pumping to supply the nozzles, two rows of trees are sprayed at a time. By having another man to pump the water, mix it, etc., we get out say 10,000 to 12,000 gallons per day, spraying four or five hundred large bearing trees. It is a tedious, expensive job, but a profitable one, nevertheless.”—(F. G. Sampson, Boardman, *Fla.*, May 28, 1889.)

No. 8.—*Water as an Insecticide*.—“I find that spraying a tree with water will rid it of these pests by causing them to fall to the ground, where they are effectually destroyed by the dripping from the trees.”—(A. S. Kells, Citra, *Fla.*, June 11, 1889.)

No. 9.—“By request of L. B. Wombwell, esq., I inform you that the orange leaf-mite (red spider) made frequent incursions into my grove at Montverde during the months of April and May last, but invariably disappeared upon the application of copious showers of lake water from a 2½-inch hose under a pressure of 165 pounds. The water was thrown in a stream 100 feet into the air and fell as a heavy rain. Ordinarily the whole surface of the land was watered once in five or seven days, the frequency depending upon the evaporation caused by the wind. Twice only was water applied to drive out the insect when not necessary to the land. * * * As this irrigation to wet trees and land costs, exclusive of plant, only 25 cents per acre per application, it seems to me a cheaper method than by the use of insecticides. In my grove an occasional affected leaf could be found. In neighboring groves, not irrigated, more leaves were on the ground than on the trees when I last saw them, about June 1.”—(James Franklin, Montverde, *Fla.*, July 11, 1889.)

THE HORN FLY.

(*Hæmatobia serrata* Robineau-Desvoidy.)

Order DIPTERA; family MUSCIDÆ.

[Plates IV and V.]

We have already published (*INSECT LIFE*, Vol. II, No. 4, October, 1889, pp. 92–103) a somewhat complete account of the life history of this insect, together with recommendations as to remedies, from which we may condense the more important information, mentioning also one or two additional points.

FIRST APPEARANCE, SPREAD, AND INVESTIGATION.

We first learned of this pest in September, 1887, through Mr. I. W. Nicholson, of Camden, N. J. In the spring of 1888 the same gentle-

man again wrote to us about it, and we heard of it also in Maryland. In 1889 it was found in many localities in Maryland and through Virginia south to Bedford County. The latter part of August it was found for the first time in the vicinity of Washington. It was carefully studied through the summer, mainly by our first assistant, Mr. Howard, and by Mr. Marlatt. It is probably an importation. The insect first appeared in the neighborhood of Philadelphia and gradually spread southward. It is unquestionably identical with the European species *Hematobia serrata* previously found in southern France. The exact time and place of its importation has not been traced, but the probabilities are that it came over with European cattle about 1886, imported through the quarantine station of this Department at Garfield, N. J.

POPULAR NAMES AND ERRORS.

The name "Horn Fly" has been quite generally adopted, and has reference to the habit which the flies have, particularly early in the season, of settling in large numbers around the base of the horns. It has also been called the "Texas Fly," the "Buffalo Fly," and the "Buffalo Gnat." These names indicate erroneous popular impressions that the insect came from the West.

It is an error to suppose that the fly damages the horn, yet this has been often stated in the newspapers during the past season. Some persons believe that the fly eats into the horn, causes it to rot, and lays eggs in it which hatch into maggots and thus penetrate the brain. There is absolutely no foundation for this opinion.

LIFE HISTORY.

The eggs are deposited during daylight, chiefly between 9 a. m. and 4 p. m., and more particularly during the warmer morning hours. They are laid singly and usually upon their sides upon the surface of wet dung the moment the latter is dropped. So far as known they are laid upon no other substance, and never upon old dung. The larvæ upon hatching descend into the dung, remaining, however, rather near the surface. When full-grown they are about two-fifths of an inch in length and of normal color and form. The puparium is formed in the ground beneath the dung. The time elapsing from the egg to the adult is from ten to seventeen days, averaging, say, two weeks, and there are probably seven or eight generations annually. The winter habits have not been definitely determined, but at this writing (the winter having been exceptionally mild) the species is found in the larva and pupa states. Hibernation doubtless takes place normally, either as an adult around stables or as a puparium below the surface of the ground. The flies make their appearance in May, becoming most abundant in July, and gradually dwindling in this latitude until November or until sharp frosty nights become frequent. The characteristic habit of clustering about the base of the horn is developed only when the flies are quite abundant. When they average only one hundred or so to an animal comparatively few will be found on the horn. Moreover the horn-clustering habit seems to be more predominant early in the season than later. The horns are not the only resting places, as vast numbers cluster also upon the back, between the head and fore shoulders, where they can be reached by neither head nor tail.

In the feeding position the wings are slightly elevated, and are

held out from the body at an angle of 60° from the abdomen; the legs are held out widely, and the beak, inserted beneath the skin of the animal, is held in nearly a perpendicular position. The fly, before inserting its beak, works its way through the hair close to the skin, but it is able, at a fling of the tail or an impatient turn of the head, to rise instantaneously in flight, settling back as quickly. The fly itself may be readily recognized from the figures. It is about one-half the size of the house-fly, which it resembles in general appearance.

AMOUNT OF DAMAGE.

We have seen a newspaper statement from President Alvord, of the Maryland Agricultural College, to the effect that no damage results, according to his observations, from the visitations of the insect, and that the cattle seem indifferent to it even when very numerous. He does not believe that they have caused any real damage or even much annoyance. The only way in which we can explain this extraordinary statement is by supposing that President Alvord has not seen the flies in their customary abundance. Any stock-raiser in Fauquier County, Va., or in some localities in New Jersey, would laugh at such a statement. It is true that the accounts of the damage done have been greatly exaggerated, and we have been unable to substantiate a single reported case of death resulting from the bites of the flies. There can be no question, however, but that, when as numerous as they were last summer, they affect stock injuriously, reducing flesh, while in the case of milch cows the yield of milk is unanimously stated to be reduced from one-fourth to one-half. This is a point on which dairymen can not possibly be mistaken. Col. Robert Beverly, of Fauquier County, was so certain in July that his range steers were being badly reduced in condition that he shipped them off by the car-load. There is, moreover, quite a common belief that the bites will eventually produce sores, and we have seen quite a number of cattle afflicted with large, open wounds, which were attributed to these flies. It seems to us, however, that the flies are only indirectly the cause of such spots. The irritation caused by the bites causes the animals to rub themselves violently and severely against trees and fences, and to constantly lick such points as the neighborhood of the bag and the inside of the hind thighs, which they can not well reach in any other way. The sores are probably brought about in this way.

PREVENTIVE APPLICATIONS.

Almost any greasy substance will keep the flies away for several days. A number of experiments were tried in the field, with the result that train oil, with a little sulphur or carbolic acid added, will keep the flies away for from five to six days, while with a small proportion of carbolic acid it will have a healing effect upon sores which may have been formed. Train oil should not cost more than from 50 to 75 cents per gallon, and a gallon will anoint a number of animals. Common axle grease, costing 10 cents a box, will answer nearly as well, and this substance has been extensively and successfully used by Mr. William Johnson, a large stock dealer at Warrenton, Va. Tallow has also been used to good advantage. The practice of smearing the horns with pine or coal tar simply repels them

from these parts. Train oil or fish oil seems to be more lasting in its effects than any of the other substances used.

APPLICATIONS TO DESTROY THE FLY.

A great deal has been said during the summer concerning the merits of a proprietary substance consisting mainly of tobacco dust and creosote, known as "X O dust," and manufactured by a Baltimore firm, as an application to cattle, and it has received an indorsement from Prof. J. B. Smith, entomologist to the New Jersey Experiment Station. We are convinced that this substance has considerable merit as an insecticide, and know from experience that it will kill many of the flies when it touches them, although they die slowly and a few may recover. The substance costs 25 cents a pound, and is not lasting in its effects. Where it is dusted through the hair the flies on alighting will not remain long enough to bite, but two days later, according to Mr. Howard's observations, they are again present in as great numbers as before. A spray of kerosene emulsion directed upon a cow would kill the flies quite as surely, and would be cheaper, but we do not advise an attempt to reduce the numbers of the pest by actually killing the flies.

HOW TO DESTROY THE EARLY STAGES.

Throwing a spadeful of lime upon a cow-dung will destroy the larvæ which are living in it, and as in almost every pasture there are some one or two spots where the cattle preferably congregate during the heat of the day, the dung which contains most of the larvæ will be all the more easily treated. If the evil should increase, therefore, it will well pay a stock-raiser to start a load of lime through his field occasionally, particularly in May or June, as every larva killed then represents the death of very many flies during August. This course will be found in many cases practical and of great avail, and will often be an advantage to the pasture besides.

Plaster is urged by Professor Smith as better than lime for this purpose, for the reason that it will not destroy the free ammonia in the dung and thus render it less valuable for manure. This point is worthy of consideration, and would be more so if Professor Smith's theory that the flies laid their eggs at night and around the stables and manure pits were correct. He also suggests that the mere spreading out of the fresh dung with a shovel will destroy the larvæ which it contains, for the reason that it will dry up more quickly.

THE GRAIN APHIS.

(*Siphonophora avenæ* Fabr.)

Order HOMOPTERA; family APHIDIDÆ.

[Plates I and VI.]

Since 1861 there has been no such appearance of this insect as occurred last season. For many years it has been present every spring in the wheat-fields, but, although occasionally very numerous and often reported to the Department, has never done serious damage, disappearing at the critical time through some change in the weather, or through the sudden increase of its natural enemies. During the past season, however, instead of disappearing it kept on increasing,

until in many localities its numbers became extraordinary, its natural enemies not gaining the upper hand until nearly harvest time.

PAST DAMAGE.

The year 1861 is the only one in which wide-spread, serious injury has previously been recorded. In that year, in the New England States, New York, northeastern Pennsylvania, and some portions of Canada almost every grain-field was thronged with the lice. Dr. Asa Fitch carefully studied it that year, noticing it for the first time early in May on winter grain, winged individuals beginning to appear toward the close of the month. He noticed at that season that each female gave birth to four young daily, making the offspring of one female in twenty days upwards of 2,000,000. As soon as the heads of grain put forth in June the lice were observed to forsake the other parts of the plant and cluster on the heads, changing from a grass-green color to orange. He evidently did not trace the insect through the season but makes simply the general statement that, on the approach of fall, males are produced and winter eggs are laid, probably on fall-sowed wheat and rye, and that the eggs hatch in spring. He showed that in some instances in 1861 the yield of spring wheat was reduced one-half, and gave an account of such of the species of natural enemies as came under his observation.

In glancing through the bulletins of the Statistical Division of the Department we notice that the lice were reported in numbers during the following years: 1868, Rutherford County, Tenn.; 1869, Green County, Tenn.; 1874, Caroline County, Md.; 1876, Lincoln County, N. C., and Fannin County, Ga.; 1880, Aiken County, N. C., and Halifax County, Va.; 1882, "The Grain Aphis has been numerous in some of the Southern and Middle States;" 1887, "*Siphonophora avenae* did early and quite general damage to oats throughout this region" (Illinois, Iowa, Wisconsin).

Dr. Cyrus Thomas, in his report as State entomologist of Illinois for 1879, mentioned the occurrence of the Grain Aphis in great numbers in his State in 1866 and 1876, and adds to the facts given by Fitch the finding of winged and wingless specimens upon wheat during the winter of 1875, the wingless below ground and the winged above. He also states that the species works upon Barley, Oats, and various grasses.

GEOGRAPHICAL DISTRIBUTION.

The species is found all over Europe, and in this country occurs from Canada to North Carolina and perhaps farther south. It is found all through the western grain-growing States and is reported as doing some damage in California, although specimens from the west coast have not been authentically determined. They have a grain-louse there, however, working in the same way as in Eastern wheat-fields, and it is probably the same species.

LIFE HISTORY.

The life history of the species has by no means been made out with the accuracy with which we should like to be able to present it, although for a number of years past we have been seeking the missing links in its full life cycle. The points not yet definitely

determined are: (1) the exact number of generations (doubtless somewhat variable); (2) the intervals between the winged generations; (3) the winter habitat, and particularly the *locus* of the winter egg. We have found wingless parthenogenetic females on wheat late in April. Winged parthenogenetic females begin to appear late in May and there is a succession of agamic generations on wheat and on oats until harvest time. The rapid increase of the insect's natural enemies at this time, however, practically exterminates it about this time and renders it extremely difficult to continue observations whether in the field or the vivaria. We particularly urged and instructed our Indiana agent, Mr. Webster, who was well situated to carry on the needed studies, to follow the development during this period the past season, but he signally failed. Adults placed on various kinds of grasses in breeding cages invariably died. During our absence in Europe the past summer Mr. Howard had plots of spring wheat and timothy planted on the Department grounds, and these were several times stocked with lice received from Indiana, with the result that all soon died. He also made several attempts in August to import living individuals from Canada with the help of Mr. James Fletcher, but all specimens died on the journey.

In 1884, however, we sent Mr. Pergande on a trip in the neighborhood of Washington to study the species, and while he also failed in colonizing it in breeding cages he found larvæ and pupæ about the end of June on green Rye and Oats, Red-top (*Agrostis vulgaris*), Chess (*Bromus secalinus*) and Orchard Grass (*Dactylis glomerata*), the wheat at this time being nearly all harvested. In the same way Mr. Webster found large numbers of individuals late in June on Blue Grass (*Poa pratensis*), long distances from wheat-fields, but every one was parasitized. These observations prove, however unsuccessful breeding-cage experiments may have been, that the species bridges over the gap between wheat harvest and the appearance of fall wheat by migrating to the midsummer grasses.

When fall-sown wheat makes its appearance along in September, lice are again found upon it although in very small numbers. Full-grown wingless females have been found by Mr. Webster upon fall wheat as early as September 1, and from this date on until December 30 he has found them on wheat continuously. He has also observed the sexual individuals pairing November 11 and December 3, but has failed to get the winter-egg.

From the foregoing summary of what has been observed, and from analogy in the known life habits of allied species, we may conclude that the winter-egg is laid upon winter wheat, and that, although individuals may live until late in the winter, it is in this winter-egg state on wheat that the species normally hibernates and from which the stem-mother hatches in spring to give rise to the prolific wingless generations of late spring and early summer.

NATURAL ENEMIES.

Although the natural enemies of this species play an all-important part in its economy we can not here devote any space to their specific consideration beyond enumerating and illustrating the more important of them. It is largely due to these enemies that the lice are not abundant every year and it is entirely due to their good offices that the lice so suddenly disappear, as they did the present year, in late

June and early July. The climatic conditions were exceptionally favorable to the increase of the lice, and the natural enemies were not able to multiply with sufficient rapidity to overcome them until much later in the season than usual. The season's observations have more than doubled the number of these insect enemies which had previously been observed.

LIST OF INSECT ENEMIES OBSERVED IN 1889.

BEETLES.

Podabrus tomentosus Say (family *Lampyridæ*).

Coccinella 9-notata Herbst. (family *Coccinellidæ*).

Hippodamia parenthesis Say (family *Coccinellidæ*).

Hippodamia convergens Guérin (family *Coccinellidæ*).

Hippodamia 13-punctata Linnæus (family *Coccinellidæ*).

Hippodamia glacialis Fabricius (family *Coccinellidæ*).

Coccinella sanguinea Linnæus (family *Coccinellidæ*).

Anatis 15-punctata Olivier (family *Coccinellidæ*).

Megilla maculata DeGeer (family *Coccinellidæ*).

The Coccinellids or Lady-birds are given in about the order of their relative importance.

TWO-WINGED FLIES.

Allograpta obliqua Say (family *Syrphidæ*).

Syrphus americanus Wiedemann (family *Syrphidæ*).

Sphaerophoria cylindrica Say (family *Syrphidæ*).

From this last species were reared two parasites which reduce its usefulness. They are *Bassus sycophanta* Walsh and *Hemiteles syrphicola* Riley MS.

TRUE INTERNAL PARASITES.

Aphidius avenaphis Fitch (family *Braconidæ*).

Aphidius granariaphis Cook (family *Braconidæ*), Plate I, Fig. 7.

Diceretus brunneiventris Ashmead (family *Braconidæ*), Plate VI, Fig. 1.

Isocritus vulgaris Walker (family *Chalcididæ*), Plate VI, Fig. 2.

Eucyrtus websteri Howard (family *Chalcididæ*), Plate VI, Fig. 4.

Pachyneuron micans Howard (family *Chalcididæ*), Plate VI, Fig. 5.

Tetrastichus ingratus Howard (family *Chalcididæ*).

Megaspius niger Howard (family *Proctotrupidæ*), Plate VI, Fig. 6.

Allotria tritici Fitch (family *Cynipidæ*), Plate VI, Fig. 3.

Of these internal parasites the second mentioned was the most abundant and important. We have shown at Plate I, Fig. 5, the appearance of the swollen louse after the parasite has escaped, and at Fig. 6 the appearance of the nearly developed parasite taken from the body of the Aphid.

Certain persons seeing English sparrows in the wheat fields have thought that the birds were feeding upon the lice, but Mr. C. M. Weed, who had a number shot while on wheat and examined their stomachs, states that the examination showed that it was the grain which they were after, and that they ate no lice except a few which were accidentally taken with the grain.

OTHER PLANT-LICE FOUND IN WHEAT FIELDS.

Observations are complicated by the fact that several other species of plant-lice are found in greater or less numbers upon wheat. The common Apple Plant-louse (*Aphis mali* L.) is often found on wheat after the appearance of the winged generation upon apple, and, indeed, it is a question whether this species, in view of what we know of its summer migrations, should really be known as the Apple Plant-louse any more than the Hop Plant-louse should be called the Plum

Plant-louse. Another species of the true genus *Aphis*, probably undescribed, is also often found on wheat, and an undescribed species of each of the *Aphid* genera *Toxares*, *Megoura*, *Callipterus*, and *Rhopalosiphum* are also found in the wheat fields, while according to the observations of the past summer the European *Siphonophora granaria* Kirby, following Buckton's figures and descriptions, also occurs in our wheat fields and should not be considered synonymous with *avenæ* Fabr.

PROPER NAME OF THE SPECIES.

It is tolerably certain that the species which we have been dealing with is the Fabrician *Siphonophora avenæ*, and that the species described by Kalténbach as *S. cerealis* is a synonym, while the species described by Kalténbach as *S. avenæ* is a different thing, the description corresponding exactly with our *Aphis mali*. As stated in the preceding paragraph, Kirby's *S. granaria* is a different thing, although this name was used by some writers in this country the past summer. Buckton, considering Kirby's *granaria* and Fabricius' *avenæ* identical, adopted the former name for the reason, as he says, that "Fabricius gave no description of his *Aphis avenæ*;" but a glance at the *Entomologia Systematica*, 1794 ed., shows a seven-line description, certainly enough to carry the name. Buckton probably referred only to one of Fabricius' earlier works.

CAUSES OF THE PAST SEASON'S OUTBREAK.

One of the commonest axioms connected with this insect is the association of its exceptional increase with very dry years, and in searching for the reasons why this insect multiplied so abundantly and remained so much longer in the field than usual during the past summer the natural inference is that the season must have been a dry one in the infested localities. To test the theory we have drawn up a table from data kindly furnished us by the Chief Signal Officer, General A. W. Greely, which indicates in the six States of Kentucky, Ohio, Indiana, Illinois, Wisconsin, and Michigan the average precipitation (average for all stations reporting) for the months from January to June in the years 1887, 1888 and 1889:

KENTUCKY. *

	Highest.			Lowest.			Average.		
	1887.	1888.	1889.	1887.	1888.	1889.	1887.	1888.	1889.
January	4.73	6.19	5.80	1.23	2.35	2.32	3.22 $\frac{1}{2}$	4.52	3.59 $\frac{3}{4}$
February	10.11	3.79	2.58	4.60	1.70	0.88	7.53 $\frac{1}{2}$	2.50	1.82 $\frac{1}{2}$
March	6.80	5.82	4.30	1.88	2.95	0.21	3.61	4.95 $\frac{1}{2}$	1.06 $\frac{2}{3}$
April	9.00	4.48	3.76	1.50	2.45	0.51	5.22 $\frac{1}{2}$	3.37 $\frac{1}{2}$	1.80 $\frac{2}{3}$
May	4.45	3.93	7.01	1.57	2.42	2.46	3.12 $\frac{1}{2}$	3.12 $\frac{1}{2}$	4.38 $\frac{1}{2}$
June	3.00	6.00	8.04	1.33	1.95	1.88	1.86 $\frac{1}{2}$	3.32 $\frac{1}{2}$	5.05 $\frac{1}{2}$

OHIO.

January	3.50	6.15	5.78	0.25†	1.56	0.64	2.08 $\frac{3}{4}$	3.54 $\frac{1}{2}$	3.05 $\frac{1}{2}$
February	10.75	4.03	3.58	3.05	0.75	0.42	6.98 $\frac{1}{2}$	1.77 $\frac{1}{2}$	1.47 $\frac{1}{2}$
March	4.50	8.50	3.19	0.54	1.43	0.40	2.26 $\frac{1}{2}$	3.66 $\frac{1}{2}$	1.59 $\frac{1}{2}$
April	8.28	7.00	3.16	1.13	0.66	0.38	3.86 $\frac{1}{2}$	2.05 $\frac{1}{2}$	1.91 $\frac{1}{2}$
May	6.25	7.50	8.22	1.28	2.00	1.65	3.00 $\frac{1}{2}$	3.79 $\frac{1}{2}$	3.78 $\frac{1}{2}$
June	6.67	6.89	7.80	1.69	1.59	1.37	4.02 $\frac{1}{2}$	3.40 $\frac{1}{2}$	4.21 $\frac{1}{2}$

* Defective for 1887 on account of small number of station returns.

† For twenty-four days.

MICHIGAN.

	Highest.			Lowest.			Average.		
	1887.	1888.	1889.	*1887.	1888.	1889.	1887.	1888.	1889.
January	5.10	5.07	4.00	0.86	0.48	1.00	3.18 $\frac{1}{3}$	2.00 $\frac{5}{8}$	2.12 $\frac{1}{2}$
February	7.16	3.83	4.38	1.20	0.50	0.57	4.50 $\frac{1}{2}$	1.83 $\frac{1}{2}$	1.70 $\frac{1}{2}$
March	2.35	4.66	2.27	0.22	1.25	0.04	1.25 $\frac{1}{2}$	2.72 $\frac{1}{2}$	0.99 $\frac{1}{2}$
April	3.44	5.49	4.26	0.41	0.91	0.10	1.38 $\frac{1}{2}$	1.95	1.45 $\frac{1}{2}$
May	4.30	6.15	7.32	0.70	1.69	1.16	2.21 $\frac{1}{2}$	3.56 $\frac{1}{2}$	4.21 $\frac{1}{2}$
June	5.64	4.98	7.36	0.43	0.45	1.47	2.49 $\frac{1}{2}$	2.54 $\frac{1}{2}$	4.32 $\frac{1}{2}$

INDIANA.

January	4.55	5.83	4.96	0.50	1.18	1.05	2.14 $\frac{1}{2}$	3.03 $\frac{7}{8}$	2.84 $\frac{5}{8}$
February	15.90	6.36	3.62	2.97	0.75	0.74	6.33 $\frac{1}{2}$	2.25 $\frac{1}{2}$	1.59 $\frac{1}{2}$
March	5.58	11.05	2.46	0.65	1.78	0.80	2.45 $\frac{1}{2}$	4.70 $\frac{1}{2}$	1.45 $\frac{1}{2}$
April	10.78	4.13	2.24	1.12	1.00	0.55	4.06 $\frac{1}{2}$	2.25 $\frac{1}{2}$	1.10 $\frac{1}{2}$
May	6.10	7.79	9.25	1.25	1.50	2.90	3.41 $\frac{1}{2}$	3.87 $\frac{1}{2}$	5.50 $\frac{1}{2}$
June	5.98	8.64	7.32	0.10	1.37	2.60	2.54 $\frac{1}{2}$	3.70 $\frac{1}{2}$	4.68 $\frac{1}{2}$

ILLINOIS.

January	4.56	7.59	4.61	0.43		1.01	1.91 $\frac{1}{2}$	2.25 $\frac{1}{2}$	2.23 $\frac{1}{2}$
February	9.83	3.90	4.87	0.22	0.08	0.59	4.66 $\frac{1}{2}$	1.84 $\frac{1}{2}$	1.76 $\frac{1}{2}$
March	6.56	6.59	4.34	0.35	0.09	0.70	2.23 $\frac{1}{2}$	3.51 $\frac{1}{2}$	1.62 $\frac{1}{2}$
April	6.30	3.50	4.30	0.38	0.08	0.12	2.37 $\frac{1}{2}$	1.78 $\frac{1}{2}$	2.02 $\frac{1}{2}$
May	6.50	8.86	10.63	0.80	0.24	1.91	2.72 $\frac{1}{2}$	5.01 $\frac{1}{2}$	4.81 $\frac{1}{2}$
June	3.73	9.77	11.49	0.07	0.12	1.50	0.64 $\frac{1}{2}$	4.34 $\frac{1}{2}$	5.10 $\frac{1}{2}$

WISCONSIN.

January	2.69	3.55	3.75	0.25	1.16	1.41	2.03 $\frac{1}{2}$	1.86 $\frac{1}{2}$	2.27 $\frac{1}{2}$
February	5.16	3.60	3.45	1.36	0.61	0.88	3.79 $\frac{1}{2}$	1.63 $\frac{1}{2}$	1.93 $\frac{1}{2}$
March	2.14	5.69	1.42	0.26	1.70	0.20	1.17	3.21 $\frac{1}{2}$	0.75 $\frac{1}{2}$
April	2.70	3.38	10.38	0.96	1.81	0.50	1.58 $\frac{1}{2}$	2.67 $\frac{1}{2}$	1.50 $\frac{1}{2}$
May	2.50	6.30	8.05	0.50	2.21	2.30	1.46 $\frac{1}{2}$	4.48 $\frac{1}{2}$	4.12 $\frac{1}{2}$
June	4.50	7.00	9.82	0.41	1.11	1.50	1.76	3.33 $\frac{1}{2}$	3.77 $\frac{1}{2}$

Examining this table for points in common in the six States, and which are at the same time peculiar to the season of 1889, we notice that the months of February, March, and April were very dry, and that in May and June there was a sudden and very marked increase in precipitation holding over the entire region. May and June, however, were the very months in which the insects were most abundant and were oftenest reported, and in this very fact is a seeming refutation of the accepted theory. We have had occasion to disprove a similar prevalent belief in the connection between great Army Worm years and drought, and to show that wet, cloudy weather rather favors the development of the worms (Third Report U. S. Entomological Commission, pp. 114, 115). So far as plant-lice are concerned, they almost all thrive best during cloudy or wet weather and moderate temperature, as represented by the ordinary spring, rather than during dry, and especially during hot weather. Heavy storms or thunder showers, or continued drenching rains, on the contrary, are detrimental to them, and by the exceptionally heavy and continued rains which characterized the summer in the Atlantic States may be explained the relative scarcity of the Grain Aphis there this year, as compared with the States farther west, where the precipitation was less. A few calm, temperately warm, and fair days at the proper

season to favor migration and spread will have more to do in determining injurious increase than the character of the weather for weeks or months afterward, while the nature of the preceding winter may also be all-important. This we have clearly shown in reference to the Hop Plant-louse, and also of other species which we have studied.

The explanation of the prevalence of the Grain Aphis the past summer is to be found, then, in the early spring months so favorable to Aphid increase, and in the subsequent absence of the usual hot spells, the summer temperature having been exceptionally low and equable, rather than in exceptional increase or decrease of rain. If anything, a rainy summer will promote increase for much the same reason which we have given at length in discussing its influence on the increase of the Cotton Worm (Fourth Report U. S. Entomological Commission, pp. 83-85). The rain unquestionably prevents the work of many of the enemies of the plant-lice which we have enumerated, and particularly the delicate little parasites of the braconid sub-family *Aphidiinae*. These are minute four-winged creatures, which fly with a swift, darting motion from plant to plant, laying an egg first in one louse and then in another, their development being exceedingly rapid. Now rains deprive these parasites of their means of locomotion to a greater or less extent. Observations have proved that while the wings of allied parasitic hymenoptera dry slowly, the insects themselves may be partially immersed in water for hours without dying. Hence a rainy season tends to check the work of these parasites, but the rain once over they are ready, after their wings dry, to carry on their, to us, beneficent work. During wet weather, therefore, the plant-lice, unhampered by their foes, will increase with all the greater rapidity, providing other conditions of increase are favorable.

In this connection, and as emphasizing the foregoing generalizations, it may be stated as another important fact, that the plant-lice are more active in a lower temperature than are their numerous parasites, which flourish and multiply most rapidly in the heat of summer.

REMEDIES.

Working, as this insect does, all through a close-growing field of wheat, acres in extent, the application of insecticide mixtures is out of the question, and to experiment with them as some entomologists have done the past summer is a mere waste of time. We know that a dilute kerosene emulsion will kill them, but it can not be practically applied. Then, too, the insect lives as readily upon Oats, Barley or Rye, and also upon a number of wild and cultivated grasses, and if it were destroyed upon or with any one food-plant its numbers upon others would not be affected. It has (at least so far as we now know) no permanent and alternate winter resting plant upon which we can attack it as we can attack the Hop Louse upon Plum, and altogether the problem of remedies is one which can not be solved, for the present at least. No one has ever suggested a practical remedy, and we find ourselves unable to do so now. We agree with Professor Forbes when he says:

* * * There is probably nothing to be done with it that is of any practical value. So sensitive a creature can best be left to the Weather Bureau and its natural enemies. (*Orange Judd Farmer*, June 29, 1889, and other Western papers of about the same date.)

It is only once in a great while that any damage is done, and even the enormous numbers of the past season have, according to statistical reports, not seriously affected the wheat and oats crops as a whole.

We have already shown that the probable place of deposit of the majority of the winter-eggs is upon winter wheat, and consequently much less damage is to be expected in the purely spring wheat belt. Where only winter wheat is grown the damage, although greater than in the exclusively spring wheat region, will probably be less than in localities where both spring and winter wheat are raised, on account of the migration of the first generation of winged lice from winter wheat to less advanced spring wheat. In the same way oats grown next to winter wheat will be more apt to suffer. This is always presupposing a favorable season for the development of the lice. In the vast majority of seasons, as experience has shown, although the lice may appear in spring in great numbers, their insect enemies are apt to check them so effectually as to prevent appreciable damage.

THE WORK OF FIELD AGENTS.

A BRIEF STATEMENT OF THE WORK OF THE FIELD AGENTS OF THE DIVISION.

Mr. D. W. Coquillett, the agent at Los Angeles, Cal., was engaged during the first half of the year in superintending the breeding and distribution of the imported *Vedalia*, and the success which has attended this work has already been pointed out.

Experiments with a view of finding a cheaper method of using the hydrocyanic acid gas against scale insects were instituted and were very successful. The expense attending the use of this gas by the new method is scarcely one-third as much as by the method formerly employed. Much of the cumbersome machinery used in the earlier work is also found to be unnecessary; and this, with the considerable reduction in the expense of the process, removes many of the objections to this means of combating scale pests, and will doubtless bring it into more general use.

We have for some time felt, as intimated in our last report, that the hopes engendered by the promise of the gas treatment and the special attention which, through Mr. Coquillett, we had devoted thereto, while fully justified, had caused some neglect of the washes which previous experiments had proved advantageous and satisfactory. We have urged the sufficiency of these, and Assistant Secretary Willets, who has been among the orange groves of California and fully comprehends the situation, has strongly seconded our efforts in his correspondence already alluded to. We desired, therefore, that Mr. Coquillett should undertake some supplementary and decisive tests with the resin soaps and compounds on trees thickly infested with the Red Scale (*Aspidiotus aurantii*). He has carried out many additional experiments with these substances with the result of rendering the washes more effective, and of obtaining valuable facts regarding the method of application, and the season when the treatment will be followed with the best results.

The best solution for use during the hotter part of the year is prepared as follows: Resin, 18 pounds; caustic soda (70 per cent. strong), 5 pounds; fish-oil, 2½ pints; water to make 100 gallons.

The necessary ingredients are placed in the boiler and a sufficient quantity of cold water added to cover them; they are then boiled until dissolved, being occasionally stirred in the meantime, and after the materials are dissolved the boiling should be continued for about an hour, and a considerable degree of heat should be employed so as to keep the preparation in a brisk state of ebullition, cold water being added in small quantities whenever there are indications of the preparation boiling over; too much cold water, however, should not be added at one time, or the boiling process will be arrested and thereby delayed, but by a little practice the operator will learn how much water to add so as to keep the preparation boiling actively. Stirring the preparation is quite unnecessary during this stage of the work. When boiled sufficiently it will assimilate perfectly with water and should then be diluted with the proper quantity of cold water, adding it slowly at first and stirring occasionally during the process. The undiluted preparation is pale yellowish in color, but by the addition of water it becomes a very dark brown. Before being sprayed on the trees it should be strained through a fine wire sieve or through a piece of Swiss muslin, and this is usually accomplished when pouring the liquid into the spraying tank, by means of a strainer placed over the opening through which the preparation is introduced into the tank.

The preparing of this compound would be greatly accelerated if the resin and caustic soda were first pulverized before being placed in the boiler, but this is quite a difficult task to perform. Both of these substances are put up in large cakes for the wholesale trade, the resin being in wooden barrels, each barrel containing a single cake weighing about 375 pounds, while the caustic soda is put up in iron drums containing a single cake each, weighing about 800 pounds. The soda is the most difficult to dissolve, but this could doubtless be obviated by first dissolving it in cold water and then using the solution as required.

These experiments, together with those recorded in our previous reports, establish the value of the resin washes against scale insects, and show conclusively that the complete control of the latter may be effected by a thorough use of these substances.

The Eureka Insecticide of E. Bean, Jacksonville, Fla., was also tested and failed to furnish results of value against the scale insects.

Mr. Albert Koebele, the agent of the Division at Alameda, Cal., returned from his successful trip to Australia in April, and after repairing to Washington for personal consultation before we left for Paris, proceeded to his post at Alameda, Cal. Some time was taken up in writing out his report upon work done in Australia, which has been published as Bulletin 21, and also in assisting in raising and distributing the Australian ladybird in the northern part of the State.

His work has otherwise consisted in breeding and studying various injurious insects that have attracted attention and in collecting and preparing a lot of valuable museum material. Among the insects studied and worthy of particular mention were the wood-boring beetle known as *Polycaon confertus*, which damages fruit trees, and the western representative of our Twelve-spotted Squash-beetle, *Diabrotica soror*, of which he was fortunate enough to find an important parasite. This parasite seems to have been discovered in 1886 by Mr. Alex. Craw, of Los Angeles, and the present season both Mr. Coquillett and Mr. Koebele have succeeded in breeding it. Mr.

Coquillett has published a scientific description of the species in *INSECT LIFE*, vol. II, p. 233, naming it, in honor of its discoverer, *Cela-toria crawii*. The Western Tent Caterpillar, *Clisiocampa californica*, has also been studied and a number of parasites reared. Considerable attention has also been paid to the cut-worms of the western coast. A careful study has been made of the Codling Moth and we are pleased to be able to announce that several new parasites have been bred from it, among them a parasite of the egg. These extremely beneficial insects we hope soon to report upon in full. Most of them are not found in the Eastern States and there may be a chance of bringing some of them East. Interesting studies have also been made upon the Hessian Fly, which is becoming more abundant in California, and also upon certain grasshoppers.

The work of the Missouri agent, Miss Mary E. Murtfeldt, may be summarized as follows:

Experiments which we arranged to have made with ammoniacal solutions of white arsenic on a large number of injurious insects proved unfavorable to its use on account of the injury to the foliage. Experiments with arsenic in simple aqueous solution proved the efficacy of this substance in most cases, and it was found to be less injurious to the foliage than when used with ammoniacal solutions.

Experiments with Pyrethrum in powder and in liquid suspension gave results which corroborated its value within the limits we have set forth in previous writings.

She tested also a new exterminator known as "X O Dust" and found it effective against plant-lice, cabbage bugs, and a few other soft-bodied species. Its action seemed to be much like that of Pyrethrum powder, which it scarcely equals in strength.

Other poisons and substances were also tested but have not yet been reported upon.

A small leaf-beetle, the larva of which was extremely destructive to Spinach, was carefully studied, as it is new to the list of injurious species. This insect is *Disonycha collaris* and has been reported upon in full.

A rose slug (*Cladius isomera*), not heretofore observed in that section of the country and which produced several successive broods, was also studied and experimented upon.

A small bug (*Cosmopepla carnifex*) was also noted as a new foe in the flower garden, appearing upon roses, chrysanthemums, and other valuable plants in great numbers. Other insect enemies were studied as to obscure points in their life history. The season was characterized by an almost phenomenal scourge of plant-lice. Scarcely any kind of vegetation escaped their blighting influence in the early part of the season and considerable loss in grain and other crops resulted.

The Iowa agent, Prof. Herbert Osborn, has, in addition to continuing his work upon insects affecting domestic animals, devoted most of his time to the study of insects affecting meadows and pastures as connected indirectly with his main work. The ground covered by this latter subject is so great that the present season has been devoted mainly to the leaf-hoppers and other Homopterous insects affecting pastures.

He feels sure, after his season's study, that, taking year after year, the injury caused to pastures by insects of various kinds is fully equal to the amount consumed by the stock ordinarily pastured on such land. It is evident, then, that the prevention or destruction of

the insect injuries would add an equivalent amount to the return from such lands.

A careful estimate of the number of leaf-hoppers alone gives nearly a million to the acre. This estimate was made by throwing a net down vertically and counting the area inclosed by the ring. This was repeated a number of times and an average was struck, and then this average was multiplied by the computed number of times which the area of the net would go into one acre. Professor Osborn thinks that this estimate is really far below the actual number frequently occurring during seasons when they are ordinarily abundant and greatly under the number when they have multiplied to an unusual degree. In reply to the possible objection that they are too small to consume a great amount of food and that a million leaf-hoppers would not exceed in bulk the half of a single cow it should be remembered that leaf-hoppers grow very rapidly and usually consume proportionately a great amount of food, and that they extract the most nutritious part of the grass.

The different species of leaf-hoppers accomplishing this damage have been studied in detail, and careful experiments with remedies have been made during the season. Professor Osborn is of the opinion that remedies can readily be adopted against them costing no more than from 2 to 10 cents per acre, and by means of which not only the leaf-hoppers but the destructive grasshoppers can be destroyed. He finds in the first place that many of the leaf-hoppers hibernate in grass and are tolerably active during late fall and early spring, but at these times, while the weather is cool, do not ordinarily fly to any great distance, but progress by leaping. Burning over the pastures then at this season will destroy great numbers of the pests. Cut-worms and Turf Web-worms will on the contrary not be practically affected by this remedy as they hibernate beneath the surface of the ground. A piece of ground burnt over in early spring, although surrounded by unburnt grain land on three sides, kept its color until late summer.

If deep cheese-cloth nets are made and attached to light frames 8 or 10 feet long and run rapidly over the pasture by a boy, at each sweep vast numbers can be captured at little expense.

The best remedy, however, is the use of either one of the "hopper dozers" frequently mentioned in our articles upon destructive grasshoppers, or a strip of building paper attached to a light wooden frame and coated with coal tar or gas tar and run through the fields either mounted on runners or carried by hand close to the ground. Either of these arrangements should be worked during the warm days in the fall or spring in order to catch the hibernating species before they deposit their eggs. Repeat the operation if it seems necessary in July.

The vast majority of stock-raisers will not consider it necessary to try the use of the nets or shields, but the spring or fall burning of the pasture lands is the simplest remedy and an excellent thing to do.

Professor Osborn has paid attention to other insect pests which became prominent during the season and has made the important discovery that the Dog-wood Plant-louse (*Schizoneura corni*) is identical with a plant-louse which infests the roots of grass during summer. In other words, this insect in summer lives on the roots of grass and in the fall migrates to dog-wood. The life history of this insect has been carefully worked out, and the observation, while very interesting from an entomological stand-point, may also prove to be of considerable value economically.

The Indiana agent, Prof. F. M. Webster, returned from Australia early in April, where he had been sent, as mentioned in the article on the Fluted Scale, to report upon the agricultural aspects of the Melbourne Exposition, and took up his observations at La Fayette upon insects affecting grains and grasses. He has studied the past season, particularly, the Wheat Stem-maggot (*Meromyza americana*), the Western Striped Cut-worm (*Agrotis herilis*), the Army Worm (*Leucania unipuncta*), the White Grub (*Lachnosterna* spp.), the Wheat Wire-worm (*Agriotes mancus*), the Swamp Sphenophorus (*Sphenophorus ochreus*), the Chinch Bug (*Blissus leucopterus*), and the Grain Plant-louse (*Siphonophora avenæ*). He reports upon all of these insects as well as upon some others of less importance. The principal points of interest which he brings out are the finding of another food-plant for the Wheat Stem-maggot in blue grass. He has also experimented upon the relative susceptibility of certain varieties of wheat, in which he shows that Michigan Amber is attacked with only about one-fourth of the severity of Velvet Chaff. From the Western Striped Cut-worm he has reared a new natural enemy, viz, *Anthrax hypomelas*. This is interesting as confirming some few previous notes of the parasitism of Anthrax upon Lepidopterous larvæ. Several outbreaks of the Army Worm, in which the damage has fallen upon the rye crop, are mentioned.

The life history of the Swamp Sphenophorus has been made out as detailed in Vol. II. No. 5, INSECT LIFE, November, 1889. This insect was found breeding in the roots and stems of a species of Rush (*Scirpus atrovirens*) rendering the system of prevention very easy. These plants must be destroyed root and stem the season prior to devoting the ground to corn. The most practical and probably the most effective way of destroying it is to sow rye upon the land the first season after breaking.

In regard to the Chinch Bug, he has endeavored to show by carefully tabulating the districts in the State of Indiana in which the bugs abound in years of prevalence, the districts in which the greatest amount of wheat is grown and the comparative rain-fall in the different districts, whether the immunity of certain portions of the State can be traced to climatic differences or to the nature of the principal crops.

He has experimented with fungus diseases of the Chinch Bug, distributing specimens received from Prof. F. H. Snow, of Lawrence, Kans., but the experiments were not satisfactory. He succeeded in getting the fungus established at two points in Indiana, but his experiments show that it will not prove contagious unless great masses occur and the weather be over-moist.

The facts which he collected in regard to the Grain Aphis have been referred to in the article upon this subject which appears in the early portion of this report.

The work of the agent stationed in Nebraska, Mr. Lawrence Bruner, has been somewhat diversified. He has continued work on the family Acridiidae, which includes all of the destructive locusts or grasshoppers, and in this line reports the present year upon an investigation of a reported locust outbreak at Nephi City, Utah. The species concerned were mainly local and non-migratory, although a few specimens of the Rocky Mountain Locust (*Melanoplus spretus*) and the Destructive Cricket (*Camnula pellucida*) were found. There seems to be no reason, however, for alarm another season. The outbreak of the Rocky Mountain Locust in Minnesota, referred to in the

introduction to our last report, has been completely stamped out by the energetic work of Mr. Otto Lugger, the entomologist of the station, with the intelligent co-operation of the State authorities. There was, therefore, no necessity for Mr. Bruner's services in this part of the country.

Mr. Bruner reports an interesting case of the fungus disease of a local species of locust in the vicinity of Lincoln, Nebr. The large Differential Locust (*Melanoplus differentialis*) was destroyed by this. The fungus causing the disease is known as *Entomophthora calopteni* Bessey. Some study was made of this disease and large numbers of the dead locusts were collected.

An important study which we have had Mr. Bruner take up the past season is that of the insects detrimental to the growth of young trees on tree claims in Nebraska and other portions of the West. Little more was done the present season than to collect and tabulate the species thus engaged. About thirty species of importance were observed, distributed as follows: Two saw-flies, six beetles, fifteen caterpillars, two tree crickets, and three locusts. The causes of injury have been studied and comparative freedom of different plants tabulated. He finds that of the trees and insects observed the Catalpa and Russian Mulberry are not damaged, the Ash is affected by three, the Box Elder by two or three, the Willow by a dozen or more, the Cottonwood by four or five, the Soft Maple by several, the Elm by two and the Honey Locust by two. Only such insects have been studied as attack the young trees during their first year's growth. Other species commence their injuries on the trees later on.

The Army Worm was recorded for the first time in the State of Nebraska in injurious numbers. The Blue Grass Weevil he has fortunately succeeded in finding in all stages. The species is known as *Sphenophorus parvulus*, and Mr. Bruner has found that it lays its eggs at the roots of blue grass (*Poa pratensis*) and that two generations appear during the year, one in the spring and the other in the early fall. There is a possibility, however, that it is only single brooded and that the individuals appearing in the fall are only advance specimens and winter over as beetles. The Corn Root-worm (*Diabrotica longicornis*) is reported as becoming alarmingly common in eastern Nebraska, while the Corn Ear-worm (*Heliothis armigera*) has done considerable damage to the ears of field corn.

NOTE.—For explanation to plates see p. 361.



THE GRAIN PLANT-LOUSE AND ITS ENEMIES.

Sackent & Wilhelm, Litho. New York



Fig 1



Fig 2



Fig 4 a



Fig 4 b



Fig 4 c



Fig 3



Fig 4

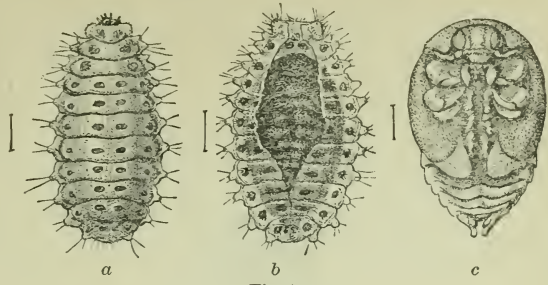


Fig. 1.



Fig. 2.

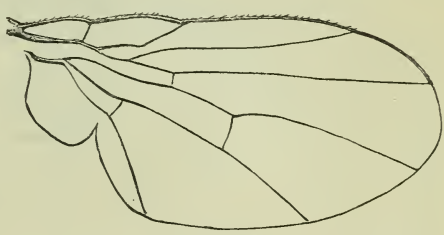


Fig. 4.



Fig. 6.

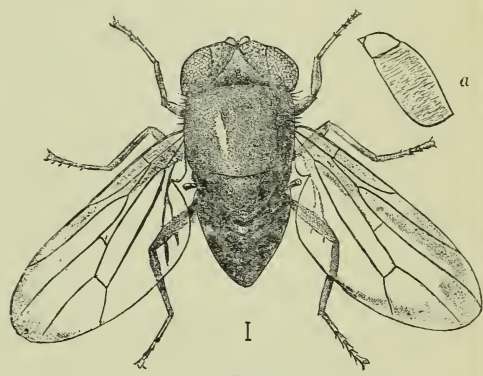


Fig. 3.



Fig. 5.

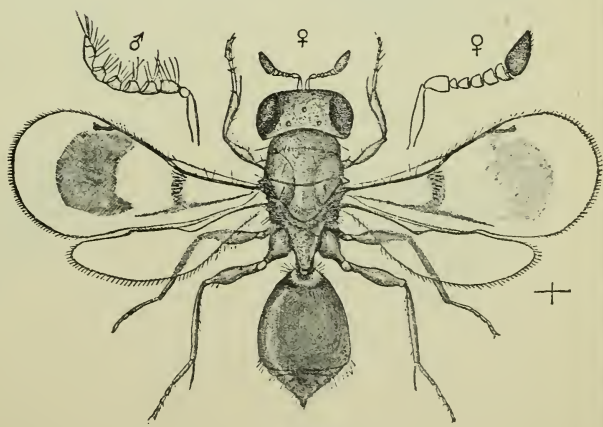


Fig. 7.

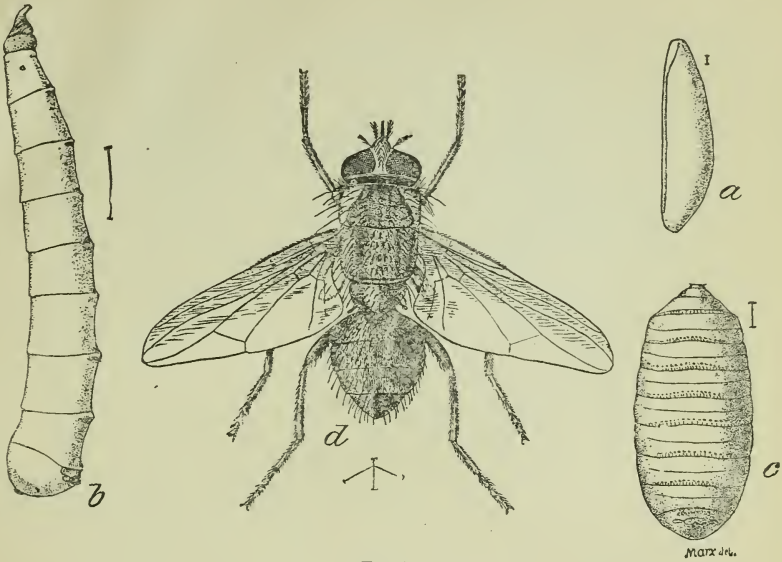


Fig. 1.

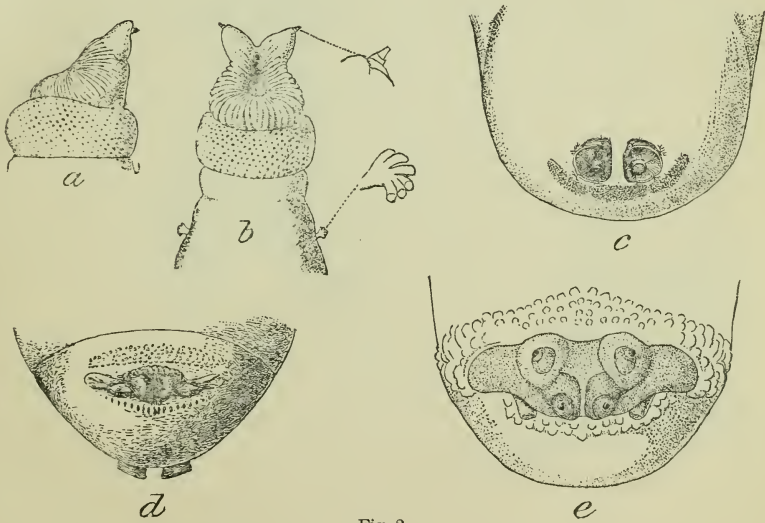


Fig. 2.

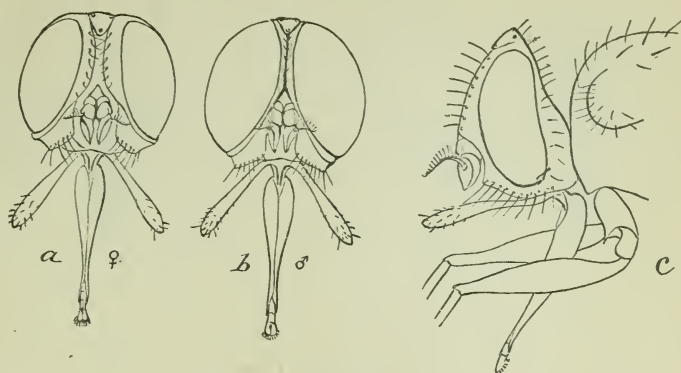


Fig. 1.



Fig. 2.

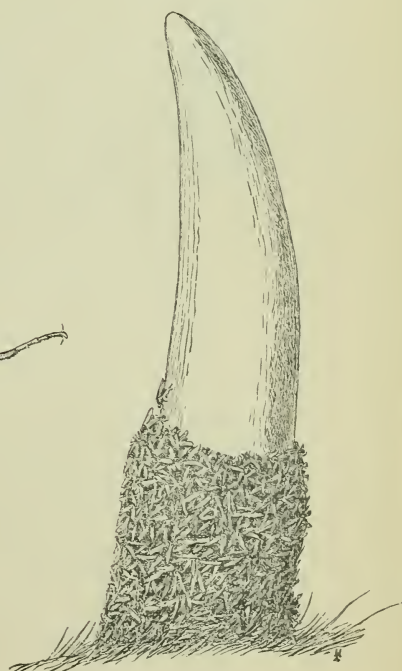


Fig. 3.

EXPLANATION TO PLATES TO REPORT OF ENTOMOLOGIST.

Where figures are enlarged the natural sizes are indicated in hair-lines at side, unless already indicated in some other way on the plate.

EXPLANATION TO PLATE I.

THE GRAIN PLANT-LOUSE AND ITS ENEMIES.

(Original.)

- FIG. 1. Head of wheat, showing lice in position in late May and June.
 FIG. 2. *Siphonophora avenae*. Wingless parthenogenetic female—enlarged.
 FIG. 3. The same, pupa of winged migrant—enlarged.
 FIG. 4. The same, winged migrant—enlarged.
 FIG. 5. The same, wingless female, with swollen body, showing exit hole of parasite—enlarged.
 FIG. 6. *Aphidius granariaphis*, nearly developed adult, taken from body of louse—enlarged.
 FIG. 7. The same—enlarged.
 FIG. 8. *Allotria tritici*—enlarged.
 FIG. 9. *Allograpta americana*—natural size.

EXPLANATION TO PLATE II.

THE SIX-SPOTTED MITE OF THE ORANGE.

(Original.)

- FIG. 1. Under surface of orange leaf, showing the work of the mite—natural size.
 FIG. 2. Upper surface of orange leaf, showing effect of the work of the mite—natural size.
 FIG. 3. *Tetranychus 6-maculatus*, adult from below—enlarged.
 FIG. 4. The same from above—enlarged; *a*, claw; *b*, proboscis and palpus; *c*, palpus—still more enlarged.

EXPLANATION TO PLATE III.

ENEMIES OF THE FLUTED SCALE.

- FIG. 1. *Vedalia cardinalis*: *a*, full-grown larva; *b*, pupa, within larval skin; *c*, pupa—enlarged. (After Riley.)
 FIG. 2. The same, adult—enlarged. (After Riley.)

- FIG. 3. *Cryptochaetum iceryae*—enlarged; *a*, antennae—still more enlarged. (After Riley.)
 FIG. 4. Wing of same—enlarged. (After Williston.)
 FIG. 5. The same, abdomen of male showing genitalia—enlarged. (After Williston.)
 FIG. 6. *Thalpochares cocciphaga*—enlarged. (Original.)
 FIG. 7. *Ophelosia crawfordi*—enlarged. (Original.)

EXPLANATION TO PLATE IV.

THE HORN FLY.

(After Riley & Howard.)

- FIG. 1. *Haematobia serrata*: *a*, egg; *b*, larva; *c*, puparium; *d*, adult in biting position—enlarged.
 FIG. 2. The same: *a*, head of larva from side; *b*, ditto from below; *c*, anal stigmata of larva; *d*, anal segment of puparium from below; *e*, anal segment of larva from below—enlarged.

EXPLANATION TO PLATE V.

THE HORN FLY.

(After Riley & Howard.)

- FIG. 1. *Haematobia serrata*: *a*, head of female from the front; *b*, ditto male; *c*, head of female from the side—enlarged.
 FIG. 2. The same: adult in resting position—enlarged.
 FIG. 3. The same: adults in resting position at base of horn—reduced.

EXPLANATION TO PLATE VI.

PARASITES OF THE GRAIN PLANT-LOUSE

(Original.)

- FIG. 1. *Dicretus brunneiventris*—enlarged.
 FIG. 2. *Isocratus vulgaris*—enlarged.
 FIG. 3. *Allotria tritici*—enlarged.
 FIG. 4. *Encyrtus websteri*—enlarged.
 FIG. 5. *Pachyneuron micans*—enlarged.
 FIG. 6. *Megaspilus niger*—enlarged.

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U. S. DEPARTMENT OF AGRICULTURE.

REPORT
OF
THE ENTOMOLOGIST
FOR
1897.
BY
L. O. HOWARD.

[FROM THE REPORT OF THE SECRETARY OF AGRICULTURE.]



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1897.

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REPORT OF THE ENTOMOLOGIST.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., July 29, 1897.

SIR: I submit herewith an executive report covering the operations of the Division of Entomology for the fiscal year ending June 30, 1897, dividing it, in accordance with the directions contained in your circular letter of June 21, into the following sections:

(1) A brief report of the operations carried on during the fiscal year 1897.

(2) An outline of proposed work for the fiscal year 1898.

(3) Suggestions as to work for the fiscal year 1899, for use in preparing estimates.

Respectfully,

L. O. HOWARD,
Entomologist.

Hon. JAMES WILSON, *Secretary.*

WORK OF THE YEAR.

The amount appropriated by Congress for entomological investigations (aside from the salaries provided for by the statutory roll) was \$20,000. Of this amount there was expended the sum of \$19,114.76, leaving an unexpended balance, which was covered into the Treasury, of \$885.24. The main items of expense may be grouped as follows: Salaries of investigators and other employees, stationed for the most part in Washington, D. C., \$13,355.70; salaries of field agents, \$958.07; miscellaneous office supplies and expenses, \$3,371.43; traveling expenses, \$1,429.56. Of the salaries for investigators and other employees the amount expended for scientific assistants has been \$9,695.70, and for clerical and other assistants \$3,660.

The work of the division may be classified, as in former years, under the following heads:

(a) Investigations upon specific injurious insects or groups of insects.

(b) Experiments with insecticides and insecticide machinery.

(c) Determination of specimens sent in by the entomologists of the State experiment stations and by other workers.

(d) General investigations of the life histories of injurious insects.

(e) Work on geographic distribution of injurious insects.

(f) Bibliographic work.

(g) Preparation of circulars of information.

(h) Correspondence.

(i) Mounting and preparation of specimens for permanent preservation.

(j) Preparation and proof reading of bulletins and reports.

(k) Work upon the exhibit of insects for the Nashville Exposition.

Briefly summarized, the work of the division under each of these heads has been as follows:

(a) The investigation of the San Jose scale, mentioned in the last two annual reports, was practically completed with the publication of Bulletin No. 3, new series, issued during the fiscal year 1896. Some supplementary investigations were made, however, during the fiscal year 1897, but these related principally to the spread of the species, the life history having already been fully ascertained and the best remedies determined. Very many new localities in the Eastern States have been found, but in this line of work the State experiment stations have shown great interest and have practically taken the investigation into their own hands, as seems eminently proper. Nevertheless, accurate records are kept at the office, so that at any time a supplementary bulletin may be published. The State experiment station workers, as well as fruit growers, however, have found great difficulty in distinguishing between the San Jose scale and several closely allied species which occur upon fruit trees. The result has been that this office has been kept busy by requests from such persons for the examination of scale insects sent in in order to decide their identity. There has, therefore, been prepared during the year a technical bulletin entitled "The San Jose Scale and its Nearest Allies; a Brief Consideration of the Characters Which Distinguish these Closely Related Injurious Scale Insects." It has been the aim in this bulletin to display by exact contrast the distinguishing characters of these allied species, so as to enable all entomologists as well as other persons who have access to a compound microscope to determine definitely whether or not the specimen before them is the San Jose scale.

The Mexican cotton-boll weevil has again attracted comparatively little attention. An agent spent some time in the field in the autumn of 1896, and it was found that owing to the extreme drought of the preceding summer comparatively little damage had been done by this insect, and it had not seriously exceeded the boundaries of spread as laid down in the fall of 1895. In the spring of 1897 the same agent visited infested points and later went to Mexico for the purpose of studying the insect in its original home, particularly for the purpose of ascertaining whether parasites exist there which could be imported into Texas with benefit.

The investigation of the insects of the household, mentioned in the last report, was duly completed and the results published in Bulletin No. 4, new series, of the division. There was a great demand for this bulletin, and the edition is practically exhausted. The same may be said of Bulletin No. 5, new series, a report upon insects affecting domestic animals, the edition of which has been exhausted for some time. A second edition has been ordered to fill the constant demand.

A supplementary investigation connected with household insects was made as to the effects of a low degree of temperature upon insects of this class. Through the kindness of one of the cold-storage companies of Washington facilities were afforded and the exact degree of temperature at which household insects and insects affecting woolen goods, furs, stored foods, etc., will remain inactive, was definitely ascertained and reported upon in Bulletin No. 6, new series. The

results of this investigation indicated the possibility of a very considerable saving to cold-storage companies and consequent possible reduction in the charges for storing goods through the summer months.

The investigation of the general subject of insects injurious to shade trees in cities and towns has been continued. Two preliminary papers have been published in the Yearbooks of the Department for 1895 and 1896, and in Bulletin No. 5, technical series, published in May, 1897, is given an account of the principal factors which brought about the almost total disappearance of tussock moth larvæ on the shade trees in the city of Washington during the summer of 1896. The investigations upon which this bulletin is based were made almost entirely during the fiscal year, and the bulletin is, in fact, a typical study of the sudden interruptions, by parasitism, which so frequently occur with many injurious outbreaks of insects of economic importance. A general report is under way.

The investigation of insects affecting stored foods, mentioned in previous reports, is making progress. New discoveries have extended its scope, and several of these have been reported upon in Bulletin No. 8, new series, entitled "Some Little-known Insects Affecting Stored Vegetable Products," published in March, 1897. A chapter on insects affecting cereals and other dry vegetable foods was published in Bulletin No. 4, new series, and a Farmers' Bulletin on insects injurious to stored grain has also been published.

Considerable time was spent during the year in preliminary work upon a general popular bulletin, to be arranged in encyclopedic form, on the principal injurious insects of the United States. This work has consisted largely in the preparation of illustrations, since it is desired to have it as fully illustrated as possible. Further, in connection with this work, sundry investigations have been carried on concerning certain insects affecting garden crops, and a preliminary paper upon the two imported asparagus beetles was published in the Yearbook for 1896.

The preparation of the extended report on insects affecting citrus fruits and fruit trees, mentioned in the last two consecutive reports, has been interrupted, temporarily at least, and very much to my regret, by a serious breakdown in the health of the investigator in charge of the work. The date of its completion, therefore, can not be approximated.

The division has devoted some time during the year to the consideration of the dangers of the importation of new insect pests from abroad. Early in the fiscal year there was published a technical bulletin entitled "Some Mexican and Japanese Injurious Insects Liable to be Introduced into the United States," and the Entomologist prepared and delivered an address before a convention of horticulturists, nurserymen, and entomologists, held in Washington in March, 1897, on the subject of the desirability of an inspection system against foreign insects, in which he considered at some length the injurious species which may at any time be brought by commerce into the United States. The convention before which this paper was read was a large and representative one, and the main result of the meeting was the drafting of a bill providing an inspection system, which was placed in the hands of Congress. The National Nurserymen's convention, held in St. Louis in June, decided upon a bill of a somewhat similar nature and urged its passage upon Congress.

The occurrence during May, 1897, of two broods of the periodical cicada has caused a very considerable demand for information regard-

ing this insect. Circulars were sent early in the season to all the localities in which this insect would probably appear, and accurate information regarding the distribution of the two broods has been gained. Work was begun upon a complete account of the life history and distribution of this insect, such as has not before been published. It will form an elaborate revision of Bulletin No. 8, old series.

Ap[ro]pos to the investigation of the Mexican cotton-boll weevil, new observations were made upon insects affecting the cotton plant, and a chapter upon cotton insects was prepared for the Handbook of Cotton Culture, published by the Office of Experiment Stations. This chapter was subsequently revised and published as Farmers' Bulletin No. 47.

During the summer of 1896 reports of grasshopper injury in Nebraska and adjoining States were received with such frequency that a special agent was employed for two months to make a tour of investigation, his report being published in Bulletin No. 7, new series.

The technical work of the division, aside from that reported upon in the two technical bulletins already mentioned, is comprised in a revision of the parasitic flies of the family Tachinidæ in North America, which has been completed and is now in the hands of the Division of Publications. Two other monographic works are approaching completion.

(b) A series of experiments with new and old insecticides has been carried on during the year, principally with relation to their effects upon foliage of different plants under varying conditions. The assistant in charge of this work visited California in the autumn of 1896 for the purpose of studying the methods of insect control in that State, and has reported in brief in the Yearbook for 1896. In May of the present year, soon after the change of administration, the Entomologist was allowed to have constructed a gasoline motor spraying apparatus of the most approved type for experimental work. This apparatus, which embodies the latest ideas in spraying machinery, does excellent work and will enable the carrying on of important experiments.

(c) The work of the division in the way of determining specimens sent in by the entomologists of the State experiment stations and by other workers in economic and systematic entomology continues to be very heavy. It was hoped that with the gradual increase of the libraries and collections of the State experiment stations this work would gradually become less onerous. Instead, it seems to be increasing. Something over 6,000 insects were named for such workers during the fiscal year, and this work consumes no small part of the time of four of the expert assistants, who are specialists in different groups.

(d) General investigations of the life histories of injurious insects are carried on in the insectary building and the adjoining garden plot. During the fiscal year notes were recorded upon 502 species which had never before been studied in the insectary. The catalogue number of the biological series of insects so studied reached on June 30, 1897, 7,625.

(e) The work on the geographic distribution of the injurious insects of the United States, which was fully outlined in the last annual report, has been slowly progressing. Additional assistance is needed in this work.

(f) The final part of Henshaw's Bibliography of American Economic Entomology, which had been in course of preparation for about ten years, was published during this fiscal year. The work as

a whole now includes five published parts, covering in all 800 pages, and bringing the bibliography from the first published paper down to July 1, 1888. Through the United States Civil Service Commission an assistant has been especially appointed to prosecute this bibliographic work. He is engaged in cataloguing the literature of American economic entomology from July 1, 1888, down to the close of the calendar year 1896. It is hoped eventually to publish this matter as a supplementary part to the bibliography already published, and thereafter to publish annual supplements. There has also been prepared and published during the year a general index to the seven volumes of *Insect Life*, the periodical bulletin published by the division during the fiscal years 1888-89 to 1894-95.

(g) Seven circulars of information concerning insects of prime economic importance were published during the year, and one of them, viz, that upon the Mexican cotton-boll weevil, in two supplementary editions—the one in Spanish and the other in German—for the benefit of cotton planters in south Texas who are unfamiliar with English. The demand for these circulars and the frequent use which is made of them in correspondence amply justifies the continuation of the series.

(h) The correspondence of the division was unusually heavy. Aside from many communications which were answered by circulars, 6,300 answers to inquiries concerning injurious insects were sent out.

(i) The connection between the Department of Insects of the National Museum and the Division of Entomology was explained in the last annual report, in which it was shown that the specimens prepared for permanent keeping are in the main deposited in the National Museum. The records for the fiscal year show an addition of 13,217 specimens to the collection, the larger share of which came through the Department of Agriculture and were deposited by the Division of Entomology, the majority of them having been mounted and prepared in this division.

(j) The publications of the division for the fiscal year will be listed in the report of the chief of the Division of Publications. In addition to the seven circulars mentioned, there have been published five bulletins of the general series, three of the technical series, Part V of the *Bibliography of American Economic Entomology*, the *General Index to Insect Life*, four articles in the *Yearbook for 1896*, and two *Farmers' Bulletins*, making a total of 1,362 printed pages.

(k) The exhibit of insects at the Nashville Exposition is practically the same as that prepared during the two previous years for the Atlanta Exposition. It required some work, however, in the way of renewing damaged specimens and altering labels. One case of new material was added and an assistant was sent to Nashville for the purpose of installing the exhibit.

PROPOSED WORK FOR THE FISCAL YEAR 1898.

The work along certain general lines indicated in the foregoing sections will be prosecuted. The Mexican cotton-boll weevil will be carefully watched. Further efforts will be made to obtain Mexican parasites, and the supplemental circular will be issued if necessary. The investigation of insects injurious to shade trees, insects affecting stored foods, insects affecting citrus fruits, geographical distribution of injurious insects in this country, bibliographical work, experimental work with insecticide machinery will all be continued. Another

investigation will be made upon the injurious grasshoppers of the far West. As explained in previous reports, it is impossible to anticipate the special subjects for investigations which it may at any time become necessary to undertake. The beginning of nearly every season brings some injurious species prominently to the front, and when this species has not already been investigated, new work must be begun. There has long been need of a complete practical bulletin on the subject of the Hessian fly. Aside from a short circular, nothing has been published by the Department concerning this insect since 1882. It is planned during the fiscal year to prepare such a bulletin, and the work has been placed in charge of Prof. Herbert Osborn, of the Iowa State Agricultural College.

A similar work relating to the chinch bug is also a great desideratum. Such a work will also be prepared during the coming year, and it has been placed in the hands of Prof. F. M. Webster, of the Ohio State Agricultural Experiment Station. For several years there has been upon the roll of the division one of the best-informed men on matters relating to apiculture in the United States. He was the author of Bulletin No. 1, new series, entitled "The Honey Bee: A Manual of Instruction in Apiculture," and has prepared a Farmers' Bulletin upon the same subject. By order of Secretary Morton the apicultural work of the division was stopped at the publication of Bulletin 1, and this assistant has recently been employed in other office work. It seems to the writer that experimental work in apiculture comes properly under the head of "Entomological investigations," and while he does not deem it wise to recommend any considerable expenditure of the small fund appropriated for such investigations in this way, he would be glad to institute, with the approval of the present Secretary, some experimental work in apiculture, utilizing the services of this assistant in its supervision. The honey producing industry is a large and growing one, and deserves some slight encouragement of this sort at the hands of the Government.

SUGGESTIONS AS TO WORK FOR THE FISCAL YEAR 1899 FOR USE IN PREPARING ESTIMATES.

The services of an additional assistant, at, say, \$1,200 per annum, could be very profitably utilized in the general work of the office, and I respectfully recommend that in the estimates of the Secretary such an assistant be added to the statutory roll. In view of what has been said in the preceding paragraph, it would seem desirable that a special appropriation of \$2,500, for experimental work in apiculture, be added to the fund for entomological investigations.

Bureau of Entomology.

U. S. DEPARTMENT OF AGRICULTURE.

REPORT
OF
THE ENTOMOLOGIST
FOR
1898.

BY
L. O. HOWARD.

[FROM THE REPORT OF THE SECRETARY OF AGRICULTURE.]



WASHINGTON:
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REPORT OF THE ENTOMOLOGIST.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., July 15, 1898.

SIR: I submit herewith an executive report covering operations in the Division of Entomology for the fiscal year ending June 30, 1898, dividing it, in accordance with the directions contained in your circular letter of June 11, into the following sections:

(1) A brief report of the operations carried on during the fiscal year 1898.

(2) An outline of proposed work for the fiscal year 1899, under appropriations already made for that year.

(3) Suggestions as to work for the fiscal year 1900, for use in preparing estimates.

Respectfully,

L. O. HOWARD,
Entomologist.

Hon. JAMES WILSON, *Secretary.*

WORK OF THE YEAR.

The amount appropriated by Congress for entomological investigations (aside from the salaries provided for by the statutory roll) was \$20,000. Of this amount, there was expended the sum of \$19,438.69, leaving an unexpended balance, which was covered into the Treasury, of \$561.31. The main items of expense may be grouped as follows: Salaries of investigators and other employees, stationed for the most part in Washington, D. C., \$13,128.88; salaries of field agents, \$2,174.16; miscellaneous office supplies and expenses, \$2,501.21; traveling expenses, \$1,634.44. Of the salaries for investigators and other employees, including field agents, the amount expended for scientific assistants has been \$11,143.04, and for clerical and other assistants, \$4,160.

The work of the division may be classified, as in former years, under the following heads:

(a) Investigations upon specific injurious insects or groups of insects.

(b) Experimental work with remedies.

(c) Determination of specimens sent in by the entomologists of the State experiment stations and by other workers.

(d) General investigations of the life histories of injurious insects.

(e) Work on the geographic distribution of the injurious insects of the United States.

(f) Bibliographic work.

- (g) Preparation of circulars of information.
- (h) Correspondence.
- (i) Mounting and preparation of specimens for permanent preservation.
- (j) Preparation and proof reading of bulletins and reports.
- (k) Work upon the exhibit of insects for the Omaha Exposition.
- (l) Work in apiculture.

Briefly summarized, the work of the division under each of these heads has been as follows:

(a) INVESTIGATIONS UPON SPECIFIC INJURIOUS INSECTS OR GROUPS OF INSECTS.

WORK ON INSECTS FROM ABROAD.

The work on injurious insects liable to be introduced into this country from foreign countries, mentioned briefly in the Annual Report for 1897, has been somewhat elaborated. The Entomologist prepared and published, in the Yearbook of the Department for 1897, an illustrated article on the "Danger of importing insect pests," and in the course of preparation of this article the principal injurious insects of foreign countries received some study. An effort has been made during the year to secure and illustrate all of the principal foreign injurious insects which have not yet reached this country and which are at any time liable to make their appearance upon our crops. A field agent has been stationed during a portion of the year in Mexico collecting injurious insects of that country and studying agricultural conditions with reference to insects.

The entomologist appointed by the Hawaiian Government spent the summer of 1897 in Mexico searching for beneficial insects, and presented the division with a complete set of the scale insects and other parasites which he collected during this work. A specific investigation has been made concerning the so-called Morelos orange fruit worm—an insect which does considerable damage in Mexico by boring into and spoiling the ripe fruit of the orange—and the introduction of which into the United States is greatly feared by citrus growers in this country. The exact distribution of this insect in Mexico has been ascertained—a point of great importance, in view of the fact that Mexican oranges are largely imported into the United States during the autumn months. The claim made by Mexicans to the effect that the worm is restricted to the small State of Morelos, and that the cry in the United States, and especially in California, for a quarantine against Mexican oranges, was not due to any legitimate fear of this insect, but to a desire to be relieved from competition with Mexico, has been disproved, and the insect has been found to abound wherever oranges are grown east of the Sierra Madre Mountains. The Entomologist, from personal observation, is, however, of the opinion that this orange worm has not yet made its appearance in the orange-growing districts of the State of Sonora, so that there need be little fear for the present of its introduction in oranges coming into California by the way of the Sonora railway. Two dangerous imported insects have been discovered during the year: one, the brown-tail moth of Europe, which has been found in injurious numbers near Boston, and the other an apple moth from Japan, which made its appearance in British Columbia just across the border from the United States.

Investigations of foreign insects have not been confined to injurious species, but some attention has also been paid to beneficial species. A step has been taken toward the introduction into California of *Blastophaga psenes*, the insect which is responsible for the fertilization of the Smyrna figs of commerce. The Entomologist visited California in the spring of 1898 and found that conditions were ripe for such an attempted introduction, Smyrna figs and caprifigs being already established in numbers at two points in the State. An agent of the Department at present in Europe will be instructed during the present fiscal year to make an effort to increase the number of varieties of caprifig now growing in California and to introduce the insect itself. Actual introductions of the insect in the spring of 1898 have shown that with the proper packing it can be brought over from Europe to California in excellent condition.

The subject of the importation of predaceous and parasitic insects has not been neglected. Arrangements have been made to attempt the introduction into this country from Europe of tree-inhabiting predatory beetles which prey upon the gipsy moth and other tree caterpillars. With the help of the Station of Agricultural Entomology at Portici, Italy, a successful importation has been made of an important parasite (*Scutellista cyanea*) of certain large scale insects. Accidental importations of two other important parasites have been discovered and arrangements have been made to further their spread in this country. An important Coccinellid enemy of Lecanium scales has been discovered in Arizona by one of the assistants of the division, and an attempt to colonize it upon the black scale in California olive groves has been prevented only by the serious illness of the assistant who was charged with the work.

THE GIPSY MOTH.

In the clause making appropriations for this division for the fiscal year ending June 30, 1898, an investigation of the gipsy moth in Massachusetts was directed. During the summer of 1897 the Entomologist made a careful study of the work which is being done under State appropriations against this imported insect pest for the purpose of deciding in accordance with the intent of the clause in the appropriation bill whether, first, the State is doing the best thing in making large annual appropriations for the purpose of endeavoring to exterminate the species, and, second, whether the work is being done in the best and most thorough way by the committee to whom it has been confided. He reported in a bulletin issued in December that, after a most careful field study extending over practically the whole summer, he was convinced that the action of the State was advisable under the circumstances and that the work is being carried on in a manner worthy of all praise.

THE SAN JOSE SCALE.

As stated in the last Annual Report, the actual investigations upon this insect conducted by the division were practically completed in 1896, the work from that point being taken up with activity by State organizations. The amount of work, however, which was done by State officers and organizations during the years 1896 and 1897 was so extensive and the results in some cases were so contradictory, that in

the spring of 1898 it was deemed desirable to publish a summary of the work accomplished which should be supplementary to previous publications by the division and should bring the status of the San Jose scale question down to date. Such a summary was prepared by the Entomologist and published in March, 1898.

THE MEXICAN COTTON-BOLL WEEVIL.

In the course of the Mexican work, referred to in a previous paragraph, efforts were made to discover parasites of this injurious insect in its native habitat which might be to advantage imported into Texas. This investigation was promised in the last Annual Report. No such parasites, however, were found. Some work was done in the field in Texas in the autumn of 1897 and more in the late spring of 1898 by a field agent of the division. The autumn work related to the spread of the species and the spring work to actual field remedies. It was shown, as predicted, that the insect has not yet spread beyond the region of the growth of volunteer cotton, and the remedial work has indicated that in addition to the cultural methods of control mentioned in previous publications by the Entomologist, much excellent work can be done in the spring by poisoning isolated stalks of volunteer cotton with a mixture of molasses and arsenic, so that early issuing weevils are killed and a greater or less amount of damage averted. The indisposition on the part of many planters to adopt the cultural methods heretofore recommended renders this poisoning work of greater value than it would otherwise be and offers a comparatively easy method of control to the small planters of a restricted region.

THE CHINCH BUG AND THE HESSIAN FLY.

During the year investigations have been made upon these two well-known and very injurious insects and a comprehensive bulletin upon each species has been completed and is now ready for the printer. By virtue of their great familiarity with the subjects and their fortunate location for the prosecution of such work, the investigation of the Hessian fly was intrusted to Prof. Herbert Osborn, of Ames, Iowa, and that upon the chinch bug to Prof. F. M. Webster, of Wooster, Ohio.

INJURIOUS GRASSHOPPERS.

As in previous years, a trip was made during the summer months of 1897 by a field agent of the division through the Western States most liable to be overrun by the Rocky Mountain locust, or Western grasshopper, for the purpose of gauging the actual damage and suggesting remedial work to farmers as well as for the more important purpose of being able to predict the probabilities of damage for the coming season. In the absence of Professor Bruner, of Nebraska, the field agent who had previously done this work for the division, his assistant, Mr. W. D. Hunter, was chosen for the work. He found that there was a general activity of the Rocky Mountain locust throughout its permanent breeding region, a greater activity, in fact, than for many years. He predicted the occurrence of the species during the summer of 1898 in South Dakota, Nebraska, and northern Kansas, but believed that the damage would be less noticeable than that done during 1897.

THE PERIODICAL CICADA, OR SEVENTEEN-YEAR LOCUST.

The predicted occurrence in May and June, 1898, of two important broods of the periodical cicada induced the preparation of an elaborate bulletin upon this species, the work being intrusted to the First Assistant Entomologist. The task was accomplished with thoroughness, and the bulletin contains by far the best and most comprehensive account of this insect yet published.

HOUSEHOLD INSECTS.

The preparation of Bulletin No. 4 of the division on the subject of "Household insects" attracted the attention of the office force to several important points connected with these insects which still required study, and a certain amount of this work has been carried on during the year. It may be worth while to mention that practical experiments, made on the grounds of the Department, have resulted in a noticeable diminution in the number of house flies in the Department buildings, and further, that an experiment upon mosquitoes on a large scale was undertaken during the spring of 1898 on Staten Island, New York, under the direction of this division, which promises good results.

GENERAL WORK IN PROGRESS.

General investigations mentioned in previous reports upon shade-tree insects, stored-food insects, insects injurious to garden crops, and insects injurious to citrus trees and fruits have not yet been completed. The necessity for a close personal investigation of the life history of each of the species concerned makes progress in this work slow. The report upon insects injurious to citrus trees, promised two years ago, is still delayed by the serious failure in health of the assistant having charge of the work. He has been obliged to remove to Arizona for his health, and to lead, as far as possible, an outdoor life. He has greatly enriched the collections of the Department by this outdoor work and has made many observations of interest, but has not been able to continue the confining work of completing his report. Mention was made in the last report of a general popular bulletin, to be arranged in encyclopedic form, on the principal injurious insects of the United States. The necessity for abundance of illustrations in such a work has delayed its completion.

TECHNICAL WORK.

No numbers of the technical series of bulletins have been published or completed during the year. The condition of the general printing fund necessitated a decision by the Secretary of Agriculture that purely technical publications should be paid from the funds of the office conducting the work, and in the case of this division the state of its funds was not such as to justify the use of any portion of them for printing.

SENDING BENEFICIAL INSECTS ABROAD.

Attracted by the success obtained in this country in the practical use of the insect enemies of destructive species, applications have been received from several foreign countries during the year for supplies of beneficial insects, and especially *Novius cardinalis*, the Australian ladybird, which has done such notable work in California against the

white or fluted scale (*Icerya purchasi*). The State board of horticulture of California has conscientiously kept a supply of living specimens of several of the Australian species continuously breeding in jars in the office of the board for the purpose of supplying applicants in different parts of the State of California. On this account there has been no effort made to perpetuate living stock of these species by the Department, more especially on account of the danger of introducing into the East the scales on which they live and of which it would be necessary to have a supply for food. Through the kindness of the California board the Division of Entomology has been able to supply several of the foreign applicants. A most notable success has been achieved in one instance, while in the others similar results are to be expected. In portions of Portugal the citrus-growing industry was threatened with extinction by *Icerya purchasi*. Living specimens of *Novius cardinalis* were sent during the autumn and winter of 1897. A small proportion of them arrived in good condition, and the latest advices indicate that they reproduced so rapidly that they are now breeding by the millions and the scale insect is rapidly being destroyed. In the same way specimens of the same insect were sent to the School of Agriculture, Ghizeh, Egypt, for use against an allied species—*Icerya ægyptiacum*. The division was also able to secure the sending of specimens of *Cryptolaemus montrouzieri* from the State board of horticulture to the Island of Madeira for use against an injurious mealy bug, and a colony of the same ladybird was obtained through the kindness of Mr. Albert Koebele, an expert in the employment of the then Hawaiian Government, and transmitted to Guatemala for use against a mealy bug which is damaging the rich coffee plantations of that republic.

(b) EXPERIMENTAL WORK WITH REMEDIES.

The insecticide work carried out during the year was in the main a continuation of work already in progress, and consisted in the experimentation with various insecticides and methods of control of insect pests. A good deal of careful work was done with hydrocyanic-acid gas, particularly in the disinfection of large quantities of seeds received from abroad and distributed by the Department, and also in the disinfection of plants and nursery material from foreign sources, also procured by the Department for distribution. Other work with this gas has confirmed the results of previous years, demonstrating its great value, not only as a means against citrus insects, for which it has been almost exclusively employed, but also as a means of controlling scale insects on deciduous trees in the East. Experiments have also been conducted with arsenicals and various oil mixtures to determine their effects on plants in dormant condition and in foliage. The experiments continued from last year with the simple arsenite of copper have again fully demonstrated the value of this substance as an insecticide to be equal, if not superior, to Paris green, which costs twice as much. It is hoped that the dissemination of this information will lead to much saving to the farmers and fruit growers who have been in the habit of using Paris green.

During the months from August to November, inclusive, the First Assistant Entomologist was granted leave of absence to visit, at his own expense, the different stations in European countries, where entomological work is carried on similar to our own. Most of the countries of southern Europe were visited, and an acquaintance was

made with the men in charge; and the methods of controlling injurious insects in the Old World were carefully studied with the view to determine their value and applicability to our own country. The conditions of climate, forest growth, and methods of culture were also studied in their bearing on the abundance or absence of injurious insects and on methods of prevention of insect injury.

(c) DETERMINATION OF SPECIMENS SENT IN.

The work in this direction continues to be heavy and consumes a considerable amount of the time of four of the expert assistants who are specialists in different groups. About the same number of insects were named for experiment station entomologists as during the previous fiscal year.

(d) GENERAL INVESTIGATIONS OF THE LIFE HISTORIES OF INJURIOUS INSECTS.

During the fiscal year notes were recorded upon 514 species which had never before been studied in the insectary. The catalogue number of the biological series so studied reached on June 30, 1898, 8,139.

(e) WORK ON THE GEOGRAPHIC DISTRIBUTION OF THE INJURIOUS INSECTS OF THE UNITED STATES.

This work has been carried on through the year, but progress is slow. Additional circulars have been sent out to all persons in the United States whose assistance, through expert knowledge, is liable to be of value. Very many records have been mapped during the year, and with a number of species the distribution begins to be tolerably plain.

(f) BIBLIOGRAPHIC WORK.

Great progress has been made in this branch during the year. The bibliography of the more important articles on North American economic entomology has been completed from the close of the Henshaw Bibliography (June 30, 1888) down to the close of the calendar year 1896, and this portion has been published as Part VI of the Bibliography. It covers the period since the establishment of the State agricultural experiment stations, a period which has been rich in publications on this subject. Nearly 4,000 titles of articles upon American injurious insects are recorded in this work. In addition, a general current bibliography of works and articles on entomology has been kept up.

(g) PREPARATION OF CIRCULARS OF INFORMATION.

Nine of these circulars concerning insects of prime economic importance were published during the year. The demand for these circulars continues, and the series, which at this date numbers 36, including 5 which have been published since June 30, 1898, is beginning to have a marked effect on the amount of labor required in the general correspondence of the office.

(h) CORRESPONDENCE.

The correspondence of the office during the year has been larger than during any previous year in the history of the division. About

6,500 letters were written in answer to inquiries concerning injurious insects, and other inquiries were answered by means of circulars.

(i) MOUNTING AND PREPARATION OF SPECIMENS FOR PERMANENT PRESERVATION.

This branch of the work has been more onerous than usual. The time of two assistants has been constantly engaged in this preparation of specimens. Very valuable additions to the collection of the U. S. National Museum have in this way been made through the U. S. Department of Agriculture. The relations between the two institutions are such that the National Museum collections are as much a part of the equipment of this division as its own library and working material, the advantage of the fireproof museum building more than compensating for the distance between the offices.

(j) PUBLICATIONS.

On account of the fact that this branch of the work is covered in the report of the chief of the Division of Publications of the Department, it will suffice to state that in addition to the 9 circulars previously mentioned, there have been published 3 Farmers' Bulletins, 2 Year-book articles, 6 bulletins of the general series, and Part VI of the Bibliography, making a total of about 1,000 printed pages.

(k) THE EXHIBIT OF INSECTS FOR THE OMAHA EXPOSITION.

In the main the same exhibit was made at Omaha that was made at Nashville. It is a general collection illustrating the specific insects of certain crops classified in accordance with the crops. Insects of crops which are peculiarly Southern in their character were, however, excluded from the Omaha series, and other series, such as that illustrating the insects injurious to the sugar beet, were added, while others of prime importance to Western agriculture, such as insects injurious to live stock and to forage crops and grains, were elaborated.

(l) WORK IN APICULTURE.

The work in apiculture has included during the year the answering of numerous inquiries as to bee management, diseases and enemies of bees, the best races, the sources of information, etc. One bulletin, entitled "Bee keeping," was issued as Farmers' Bulletin No. 59. An extensive experiment in the outdoor wintering of bees was conducted and has given, with experiments and observations concerning honey-producing plants, valuable data for future publications on these special topics.

PROPOSED WORK FOR THE FISCAL YEAR 1899.

As explained in previous reports, it is impossible to anticipate special subjects for investigations which it may at any time become necessary to undertake. This condition of affairs was markedly illustrated the present season by a sudden increase of correspondence with regard to the cottony maple scale, an insect which occasionally more or less seriously damages maple shade trees. There had been

no general appearance of this insect in injurious numbers for many years until the present season, but suddenly with the beginning of the summer of 1898 the species made its appearance in alarming numbers over a large portion of the Northeastern United States, from New England to the Mississippi Valley, and it was soon ascertained that previous publications regarding its life history were incorrect in vital points, and a reinvestigation of the species was necessitated. This outbreak and needed investigation could by no means have been anticipated last year. The work in certain general directions, as indicated in previous sections of the report, will be prosecuted. Experimental work in apiculture, in the investigations of the insects affecting garden crops, shade trees, and stored grain, will be continued. Another investigation of injurious grasshoppers in the West will be made, together with autumn and spring investigations of the Mexican cotton-boll weevil for the purpose of ascertaining the spread of the species and of trying practical remedies on a large scale.

NEED OF INVESTIGATIONS IN THE WEST INDIES.

With the greatly increased commercial relations which will undoubtedly follow between this country and Puerto Rico and Cuba there will be immediate danger of the introduction of an indefinite number of insects injurious to agriculture. This danger will not exist in the case of Hawaii, owing to the admirable system of inspection which is carried on under the State board of horticulture of California at the port of San Francisco. Moreover, the Hawaiian Government has for some years employed an official entomologist, and the injurious insects of that archipelago are comparatively well known. Of the insects of Cuba and Puerto Rico, however, we are in comparative ignorance, and at least a preliminary investigation of the crop pests of these islands should be made at as early a date as possible. If funds for the purpose can be provided by Congress, I would urge that this work be undertaken with the beginning of the fiscal year 1899

SUGGESTIONS AS TO WORK FOR THE FISCAL YEAR 1900, FOR USE IN PREPARING ESTIMATES.

I wish to urge an additional appropriation of \$2,500 for the purpose of experimental investigations in apiculture. There has been a great demand for such work from the bee keepers of the country, and an outline plan of work promising valuable results, which has been drawn up by an expert in apiculture connected with the division, has convinced the writer that such an appropriation may be made to yield good results. I wish also to urge that an additional assistant at a salary of \$1,200 be provided for. In the work which is now going on and the plans in view for the future the office force is shorthanded.

In accordance with the reasons set forth above, I also recommend that Congress be asked for an additional appropriation of \$5,000 for the purpose of making a careful study of the insects injurious to agriculture which are liable to be introduced into this country from Cuba and Puerto Rico.

Bureau of Entomology.

U. S. DEPARTMENT OF AGRICULTURE.

REPORT
OF
THE ENTOMOLOGIST

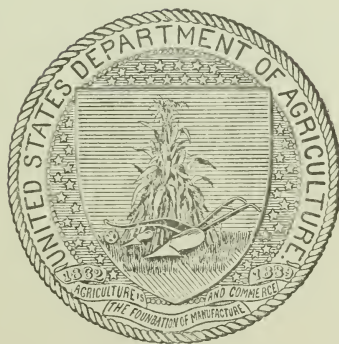
FOR

1903.

BY

L. O. HOWARD.

[FROM ANNUAL REPORTS, DEPARTMENT OF AGRICULTURE.]



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1903.

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REPORT OF THE ENTOMOLOGIST.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., August 26, 1903.

SIR: I submit herewith an executive report covering operations in the Division of Entomology for the fiscal year ending June 30, 1903, dividing it, in accordance with the directions contained in your circular letter of June 25, into the following sections:

(1) A brief review of the operations carried on during the fiscal year 1903.

(2) An outline of the plans proposed for the work of this Division for the fiscal year 1904 under appropriations already made for that year.

(3) Suggestions as to work recommended for the fiscal year ending June 30, 1905, for use in preparing estimates.

Respectfully,

L. O. HOWARD, *Entomologist.*

Hon. JAMES WILSON, *Secretary.*

WORK OF THE YEAR.

The work of the Division of Entomology during the past fiscal year may be classified as follows:

Work on insects from abroad.

Work on scale insects.

Work on the Mexican cotton boll-weevil.

Investigations of insects damaging forests.

Work on the codling moth in the Northwest.

Investigations of insects injurious to truck crops.

Work on insects injurious to stored products.

Work on insects affecting ornamental plants.

Work in silk culture.

Apicultural investigations.

Experimental work with insecticides.

Investigations of insects in their direct relation to the health of man.

Work on insects injurious to shade trees.

Unclassified work on injurious insects.

Work on the geographical distribution of injurious insects in the United States.

Technical work.

Bibliographical work.

Correspondence.

WORK ON INSECTS FROM ABROAD.

THE ASIATIC LADYBIRD ENEMY OF THE SAN JOSE SCALE.

A rather complete statement was made in the report of last year on the status and future outlook of the *Chilocorus similis*, the ladybird enemy of the San Jose scale, found in China and Japan and imported into this country to attack this scale insect on our deciduous fruit trees. During the late summer of 1902 eight colonies of this beetle were distributed to six States. These colonies were in the main put in the charge of entomologists of State experiment stations. In the case of the local colony in the experimental orchard of this Division on the grounds of the Department, the insect wintered well out of doors and started breeding early the present season. This summer some 26 colonies have been distributed in the States of Alabama, Delaware, Georgia, Maryland, North Carolina, New Jersey, New York, Ohio, Oregon, Tennessee, Virginia, and West Virginia. One colony has been dispatched, by request, to the Government entomologist of Cape Colony. Of the distributions of last year, those sent to Georgia have given the best promise. One of these, established in a large orchard of 17,000 peach trees, with a contiguous orchard containing 250,000 trees, both orchards infested with scale, shows especially satisfactory results. An examination of this orchard made by an agent of this office in July, 1903, shows that the ladybird has spread throughout the original orchard of 17,000 trees and now occurs there to the number of 30,000 to 40,000, and as there will be three additional broods this year, the present numbers should be very vastly augmented and some good results should be achieved. A considerable series of new colonies have been distributed from this orchard in various parts of Georgia. The results, therefore, of a single year's experience with this insect are, on the whole, very encouraging. Every effort will be made to quickly distribute this beetle throughout the regions where the San Jose scale occurs. The fact that this introduction is still in the experimental stage should not be forgotten, and too great hopes should not be placed upon it, and the recommendations for the prompt application of sprays and other remedial treatments should not be neglected.

THE FIG-FERTILIZING INSECT.

The year was a very successful one for the growth of the Smyrna fig. Large crops were raised at Fresno, Cal., and the quality of the figs seems to have been even better than during the previous year. The methods of packing were improved, a number of new orchards of Smyrna fig and caprifig have been started, and the insect has apparently become thoroughly acclimatized both at Fresno and at Niles.

THE PARASITIC ENEMY OF THE BLACK SCALE.

The important enemy of the black scale, *Scutellista cyanea*, originally imported by the Division from Italy and colonized in Louisiana upon a wax scale, later imported from South Africa and established in the olive and orange groves of California, is proving to be a success in the latter State. The first specimens were received in June, 1900, and were colonized in Santa Clara County. In the summer of 1901 they were not found, but during the past fiscal year they have been shown to have established themselves.

It is, however, in the southern part of the State that this parasite has done its best work, and here it has surpassed the most sanguine expectations both of the Division and of the California authorities. It has been established in every county south of Point Conception, is very plentiful in Los Angeles, Orange, and San Diego counties, and is still being sent out from the office of Mr. Alexander Craw, first deputy commissioner of horticulture at San Francisco. The Los Angeles commissioners distributed over 400 strong colonies at Escondido. At Pasadena they spread naturally in less than a year over a distance of half a mile. In the colonization districts over 90 per cent of the black scale has been destroyed by the parasite, and the latter is still breeding. There is a general feeling of confidence among the orchardists.

This important parasite is evidently of oriental origin, having first been described by Motschulsky from Ceylon, from which place it was evidently accidentally imported into Italy and into South Africa, in both of which localities it has taken a strong foothold upon the larger scale insects.

OTHER IMPORTED INSECTS.

The little European moth, *Erastria scitula*, whose larva feeds upon scale insects, and which was imported from Italy through the kindness of Prof. Antonio Berlese during the fiscal year 1902, was established in California under the charge of Mr. Alexander Craw, of the State board of horticulture. The insects were liberated at several places in the State of California, and the latest reports show that the prospects for acclimatization are fair, although no great good has as yet been accomplished.

The European ladybird, *Coccinella septempunctata*, sent from Hungary during the autumn of 1901, has not succeeded in the East. Those sent to California, however, have bred, and some colonies have been liberated. Should it become established this species, it is hoped, will be an important enemy of plant-lice.

The work with the grasshopper fungus reported upon during the previous year has practically been discontinued, the results of the previous work not having been satisfactory, although in a number of localities where the season was characterized by sufficient moisture the disease undoubtedly spread and killed off grasshoppers in considerable numbers. It is, however, in the dry regions that grasshoppers do the greatest damage, and under the conditions prevailing in such regions the fungus does not seem to spread.

WORK ON SCALE INSECTS.

The San Jose scale continues to be the prominent fruit pest in this group of insects. The methods of controlling it, however, receive additions and become more effective with each year. The advice issued from this office is embodied in two recently published and revised circulars giving the latest methods of control. A great deal of work has been done in the determination of scale insects for experiment stations and individuals, as in former years. This includes also the determination of considerable material received from foreign sources. On our new island possessions, notably Porto Rico, a great deal of damage from scale insects is being experienced, and this office is writ-

ten to for advice. Similar difficulties are being experienced by American colonists in Cuba. A good deal of information by letter and circular has been sent out to these localities, and steps are under way looking to the introduction of parasitic and predaceous insects to assist in keeping the scale pests in these islands under control. The importance of a complete acquaintance with the scale pests of foreign countries to enable one to detect these enemies on imported fruits and plants and prevent their unwitting introduction, and especially on material coming to this country through the direct agency of this Department, is illustrated by the fact that probably more than 80 per cent of the scale pests of prime importance now established in America are of foreign origin and came on introduced plants.

WORK ON THE COTTON BOLL-WEEVIL.

The continued spread of the cotton boll-weevil and the danger threatened the most important industry of the South by the direct prospect that it will soon reach all portions of the cotton belt resulted in the appropriation by Congress of \$20,000 for a continuation and enlargement of the work of the Division with that pest. This work was under the direct charge in Texas of Mr. W. D. Hunter, who was aided by a number of assistants.

The funds at the disposal of the Division enabled it for the first time to conduct experiments with the cultural methods of controlling the pest on a large scale. This was accomplished by entering into contract with two representative large planters in typical situations in Texas. By the terms of these contracts the planters agreed to plant, cultivate, care for, and in every way manage the crop exactly in accordance with the directions of the agent in charge. In this manner the Division was given practically complete charge of 325 acres, but without the trouble and expense of renting the land and working the crop. These experiments were located at Calvert, in the Brazos Valley, the most serious portion of the infested territory at present, and at Victoria, in the extreme southern portion of the State, where the existence of volunteer cotton furnishes the weevils with food very early in the season, thus adding an important feature to the problem that does not occur elsewhere.

At Victoria a field laboratory was fitted up where a thorough study was made of every feature of the life history of the weevil. The matter of parasites and the possibility of controlling the pest by their artificial propagation, which has always appealed strongly to many planters, received especial attention. In pursuance of this feature of the investigation the agent in charge made a trip to Mexico, where the governmental commission that has been created for the study of the weevil problem has especially concerned itself with the propagation of a mite (*Pediculoides ventricosus*) which, at least under certain conditions, has been found to destroy the larvæ of the pest. The agent made a study of the methods pursued in the laboratory of the commission at Cuernavaca, and through the courtesy of Prof. A. L. Herrera, the head of the commission, he was enabled to bring back to Texas a large number of cultures. These parasites were distributed from the laboratory at Victoria. The work is being continued this season, but the indications are decidedly that climatic conditions will

always render unobtainable in Texas whatever useful results may have been obtained in Mexico.

In spite of the fact that the field work of the Division was thrown in the most disastrous season for cotton culture in Texas in twenty-five years, the results have been of the greatest value to cotton producers and the working of the contract system has been satisfactory. The experimental fields have served as demonstrations that cotton can be produced profitably wherever the weevil occurs. Though there seems no probability that the weevil will ever be prevented by either artificial or natural checks from reaching all portions of the cotton belt, the work of the Division has indicated that it is possible to obtain a profitable return in producing the staple by no other means than a few simple expedients in planting and managing the crop. These expedients, consisting of a selection of seed, early planting, and thorough cultivation, enabled the Division to produce at Calvert, without any appreciable extra expense, a crop of 1 bale to 1.5 acres. The average production in the United States is 1 bale to 2.3 acres.

INVESTIGATIONS OF INSECTS DAMAGING FORESTS.

With the beginning of the fiscal year, July 1, 1902, a section of the Division was organized for the investigation of insects injurious to forests. Dr. A. D. Hopkins, formerly of West Virginia, was put in charge of this work, and during the year was given three assistants.

The work during the year has been carried on in cooperation with the Bureau of Forestry, and observations and investigations have been made in nearly all of the States and Territories. Rather serious troubles affecting different forests were located in many sections. Some of these are as follows:

The bark-beetle depredations on the silver pine and red fir and lodgepole pine in the Priest River Forest Reserve, Idaho.

An important wood-boring enemy of red fir near the Olympic Forest Reserve, Washington.

Bark-beetle depredations on the Monterey pine and Monterey cypress near Monterey, Cal., causing the death of the pine and transplanted cypress.

A serious trouble affecting the pines of the Rocky Mountain region from Arizona to Idaho, caused by bark beetles, and resulting in the death of a vast amount of timber in the National reserves and on public and private lands.

It was determined that the destruction of many large areas of timber which was supposed to be the result of forest fires was primarily the work of insects, the insects having killed the timber, which then offered favorable conditions for the starting of destructive forest conflagrations.

The destructive pine-bark beetle, which caused such wide devastation in the Virginias in 1891-1892, was located in western North Carolina, and evidence of the destructive work of the same species was found affecting the longleaf pine forests of eastern Texas.

A serious enemy of the wood of the boxed and fire injured longleaf pine was found in Texas, North Carolina, and South Carolina.

The cause of a serious trouble affecting girdled cypress trees where lumbering operations were carried on in the cypress swamps of the Southern States was determined.

The hickory bark-beetle was found to be causing serious depredations in Belle Isle Park, Detroit, Mich., and it was learned that the area infested by this beetle extends from New Haven, Conn., to Wisconsin, and southward to Cincinnati, Ohio.

A great many unrecorded enemies of pine, spruce, fir, cypress, redwood, oak, red fir, hemlock, etc., were found during the year, and much data secured relating to the life histories and habits of these and other injurious and beneficial forest insects.

It is estimated from this preliminary survey that the annual loss from forest insect depredations must be placed at not less than \$100,000,000. This is based on late stumpage values and wholesale prices of the commercial products.

Encouraging progress was made in the attainment of the primary object of the work, namely, the discovery and practical application of methods of preventing losses from the ravages of forest insects. The recommendations made to the Bureau of Forestry and the General Land Office of the Department of the Interior for checking the rapid spread of the pine-destroying beetles of the Black Hills were adopted, as were also recommendations for the control of the serious insect trouble affecting the pine timber on some 200,000 acres of forest and ranch land in northeastern New Mexico, and recommendations to the city of Detroit for the control of the insect affecting the hickory trees in Belle Isle Park. The cost of carrying out these recommendations will not exceed \$3,000, but it means not only the saving of threatened loss of forest property valued at many millions of dollars, but also the prevention of the crippling of great mining and commercial interests in the Black Hills representing millions of dollars.

Three field stations were established, one in the Black Hills, where extensive experiments were carried on with girdled and felled trees, and one at Tryon, N. C., where girdling experiments with pine and chestnut timber near Tryon and the cypress at Borden were carried on and a study of the life histories and habits of the principal forest insects of the Southern States was begun. A field station at Hoquiam, Wash., was also started, and experimental work and investigations of the life histories and habits of the principal enemies of the red fir, Sitka spruce, giant arbor vitae, and Western hemlock were instituted.

WORK ON THE CODLING MOTH IN THE NORTHWEST.

The work on the codling moth in the Northwest, referred to in two previous reports, was completed in the autumn of 1902. The special agent in charge completed, during the following winter, a full report on the investigation, which indicates very satisfactory results. The work of the late summer and autumn of 1902 was devoted to a large-scale demonstration of the efficacy of the measures adopted and recommended in Bulletin No. 30, new series, of this office, which was published as the result of the investigations of the calendar year 1901. The large-scale demonstration work showed to the satisfaction of all concerned that the economical control of the codling moth in the Northwest is possible. When it is remembered that this investigation was undertaken at the request of the fruit-growers' associations of Idaho, Washington, and Oregon, on the plea that they had not been able to grow apples successfully even with the careful use of the remedies found efficacious in the East, this result is most satisfactory. It was conclusively shown that

in the infested sections of the far Northwest, if no measures are used, from 85 to 100 per cent of the fruit is injured, but by an intelligent application of the preventive and remedial measures advised by this office many practical tests show that from 85 to 98 per cent of the fruit may be saved. The results of the investigation were briefly summed up in Farmers' Bulletin No. 171, published in June, 1903, and the most hearty indorsements of its value have been received from fruit growers. The full report on the investigation is now being published and will be issued as Bulletin No. 41, of the divisional series.

INVESTIGATIONS OF INSECTS INJURIOUS TO TRUCK CROPS.

The investigations of the fiscal year on insects affecting garden vegetables and small fruits were largely in the nature of studies of different species received from correspondents from various portions of the country, and of local species whose habits are little known or which are comparatively new as pests. A special study was made of the insect enemies of the sugar beet, including those which also affect table beets, spinach, and certain related plants useful as forage. A popular preliminary account of the principal sugar-beet depredators was completed, together with many illustrations of the insects in their various stages. This matter is now in the printer's hands, and will soon be made public. Reports received from various special correspondents through the country serve to show that with the increase of the beet-sugar industry, and the consequent larger acreage that will be devoted to growing the sugar beet, the insects which affect this crop will increase in destructiveness, and it is only a matter of time when special investigations will be necessary to counteract their ravages. Among the insects to which special attention has been given are the asparagus miner, numerous forms of blister beetles, the cabbage fly or maggot, several species of crickets, including mole crickets, and stalk borers of various forms, more especially the tobacco-stalk weevil, which has been ascertained to attack potato as well as tobacco, and which may become a pest with the increase of cultivation of potato in the region inhabited by this species. This latter insect has been studied by two agents of this Department, and its approximate life history has been learned. The year having proved unfavorable for experiment with methods of control, this work will be resumed as soon as opportunity offers.

WORK ON INSECTS INJURIOUS TO STORED PRODUCTS.

Work begun several years ago on this class of insects has been continued. The Mediterranean flour moth and the cigarette beetle, the former by far the most important pest in flouring mills, the latter a most pernicious enemy of stored tobacco, have continued their ravages, although the remedies which have been discovered for them seem quite efficient if millers, tobacco dealers, and others will employ them. Some of the most common insects injurious to stored cereals and cereal products have continued as injurious as in the past.

During the year considerable complaint has been made of injuries by powder-post beetles (*Lyctus* spp.) and some related insects which injuriously affect wood and similar material when used in manufactures. Much injury to valuable furniture has been incurred.

No better general remedy than bisulphid of carbon has been employed against any of these insects, although hydrocyanic-acid gas has also been used with some success. Farmers' Bulletin No. 45, a short popular treatise on the more important insects affecting stored grain, has reached its tenth edition, and with our constantly increasing knowledge of the subject, will soon require revision. Two hundred and thirty-five thousand copies of this bulletin have been distributed.

WORK ON INSECTS AFFECTING ORNAMENTAL PLANTS.

Investigations on insects of this class have been continued, particular attention having been paid to such as are troublesome on roses, and, to a lesser extent, on violets, which have already been very carefully investigated. A number of rose pests, however, are extremely difficult to deal with, and certain of these, some comparatively new and some pests of long standing, have been under more or less continuous observation with a view to ascertaining better methods for their control. Certain forms of flea-beetles and leaf-beetles have been prominent among insect enemies of plants grown for ornament, some of which had not been previously identified with injury. Considerable data have accumulated on the life economy of the fickle midge (*Sciara inconstans* Fitch) which have a practical bearing on means of preventing injuries by it in greenhouses, where it is a general pest nearly throughout our country. A second edition of the bulletin on "Insects injurious to the violet, rose, and other ornamental plants" was necessitated during the year, and this having become exhausted, a third will be issued in the near future.

WORK IN SILK CULTURE.

An appropriation to the Department of Agriculture of \$10,000 for investigations in silk culture was made by Congress for the fiscal year 1903. The Secretary of Agriculture naturally placed this investigation in the hands of this Division. Previous work by the Department in the years 1882 to 1891 had already demonstrated the possibility of raising excellent cocoons of the domestic silkworm in all parts of the United States in which the white mulberry tree will grow. Therefore, in the investigations to be undertaken at this time the whole attention of those in charge should naturally be devoted to the main practical aspects of establishing the industry. Undoubtedly the first step to accomplish should be to create a general interest in the subject, to insure the supply of leaves for food for the worms, and to educate as many persons as possible in the care of the worms, so that a crop of cocoons will be assured to any individual or company desiring to go into the reeling business. The Entomologist, during the summer of 1902, visited the silk-growing regions of Europe and investigated the establishments for the selection of pure eggs and the communities in which silk culture has its strongest hold. He also contracted for the purchase of two four-basin reels. Considerable quantities of silkworm eggs of the best races were purchased, and mulberry seeds and cuttings of the best varieties were also contracted for. During the winter and early spring eggs were sent in small quantities to all applicants who were able to assure the Department that they had at hand a proper supply of food for the worms. To those who had no food, mulberry

cuttings were sent. A small crop of cocoons was raised at the Department in the spring of 1903. Nearly all of the persons to whom eggs were sent reported that they had been able to rear the worms and produce the cocoons without great difficulty, and letters were sent informing the raisers that their cocoons would be purchased by the Department at the current European market rates. One of the reels imported from Europe was put in operation at the Department of Agriculture in Washington. Two expert reelers were imported from France, and at the close of the fiscal year reeling operations were about to begin. The establishment of the silk industry in the United States must be a matter of extremely slow accomplishment. Small appropriations by the General Government will assist in the education of an increasing class of silk raisers. The market for the cocoons is the great difficulty at the present time. The small market created by the Department out of this small appropriation is in reality an artificial one. It is necessary, however, to induce people to continue their interest in the subject; it is necessary for the education of a class of silk raisers, and for the present this method will be continued. The second of the four-basin reels was loaned to The Seri-Culture and Manufacturing Company at Tallulah Falls, Ga., where extensive planting of mulberry trees has been carried out, and where experimental work is promised.

APICULTURAL INVESTIGATIONS.

The correspondence in relation to apicultural matters has been constantly increasing, and has covered a wider range of subjects, including statistics in relation to the industry, methods of management, new inventions, natural resources of various regions, cultivation of special crops as bee forage, introduction of superior races of bees, etc.

In the autumn of 1902 a trip was made by the apicultural investigator through Nebraska and Colorado for the purpose of investigating certain conditions, especially in Colorado, regarding natural and artificial bee pasturage and the early breeding up of colonies of bees to enable bee keepers to take full advantage of the first crop of alfalfa. The recommendations made to cultivate early pollen-bearing crops, such as Russian hairy vetch, and to employ more prolific, hardy, and strong-winged bees than Italians, such as the Carniolan and Cyprian races and their crosses, have, wherever followed, resulted in a marked increase in the honey yield and in earliness and size of swarms.

At the request of the bureau of farmers' institutes of the State of New York the apicultural investigator was sent to deliver addresses at a series of institutes held in various portions of that State. These were well received, and much interest was manifested throughout the State in improved methods of apiculture.

Visitors at the apiary maintained on the Department grounds are numerous, including many teachers and normal school students, and during the summer months much of the time of the investigator is taken up in this manner, answering personal inquiries and giving practical demonstrations. Were the funds provided for the apiarian work sufficient, this portion might be acceptably done by an assistant, and these numerous interruptions would be avoided, which prevent more important work in the line of investigations.

Much material in the form of specimens of bees and their products, for use in natural history teaching in the public and normal schools,

has been furnished gratis to teachers. This tax upon the time of the investigator has been considerable, and it has been impossible to meet some of the requests.

A number of queens of select breeding have been sent this year, as in the past, to experiment stations engaged in apiarian investigations, and for testing in sections where it seemed advisable to try certain breeds or crosses.

A race of bees little known in this country, the Caucasian, native to the southeastern provinces of Russia, bordering on the Black and Caspian seas, has been under observation. It promises to be a valuable addition to the varieties already bred in this country. The workers are good honey gatherers and most remarkably gentle. The queens are quite prolific. The exact status of the race as regards hardiness has not yet been determined, although in Colorado they have not seemed inferior in wintering qualities to the Italians already there.

Further tests in the matter of methods in queen rearing and the use of small nucleus hives have been continued. The determination of the best and most economical method for rearing queens of the highest type is a subject of prime importance to the industry, and warrants the most thorough investigation that can be given it.

EXPERIMENTAL WORK WITH INSECTICIDES.

The value of the standard insecticides, both for biting and sucking insects, including food poisons and substances which kill by contact merely, has been established by many years of experiment; but, nevertheless, by the practical work of the office such standard insecticides receive each year the indorsement of additional satisfactory experience. This applies not only to the control of insect enemies of field and garden crops and fruits, but also to house pests, as illustrated by additional practical work done during the year with the hydrocyanic-acid gas treatment of houses described in the last annual report. The experimentation with petroleum oils, referred to in the former report, has been started during the present year in conjunction with the Bureau of Plant Industry and Chemistry of this Department. This work, it will be recalled, was undertaken in response to special requests from the Society for the Promotion of Agricultural Science and of the Association of Economic Entomologists. The work of this summer has been the making of preliminary field tests with the varying brands of oils coming from different sections of the United States, and also with specially prepared mixtures of oils the constituent elements of which are known, the object being to determine what constituents are beneficial and what are harmful to plants. To facilitate this experimental work in the future a young orchard has been established on the Arlington Farm for insecticide experimental purposes solely, since it has been found necessary to have a body of trees which may be subjected to any experiment whatsoever, irrespective of the probably harmful effects to the treated plants.

This office is in almost daily receipt of announcements of the discovery of insecticides and new methods of insect control. These are duly examined, and, when samples of the insecticide mixtures are sent, very often are submitted to the Chemist for report as to composition. As a rule, these substances prove to be combinations or crude imitations of well-known insecticides, and have no special merit over the latter. It

is often possible to give the devisers of these mixtures advice which will save them from the expense of copyrighting or patenting and exploiting useless substances or methods. A great deal of work of this kind has developed in connection with the boll-weevil. Any of the methods or substances suggested against the latter insect which have any promise whatever of satisfactory results are submitted to the field agent in charge of the work in Texas for practical field tests. As in former years, this office has been in active cooperation with the Bureau of Chemistry in assisting in the examination and analyses of miscellaneous insecticide substances.

INVESTIGATIONS OF INSECTS IN THEIR DIRECT RELATION TO THE HEALTH OF MAN.

Work in this important direction has been carried on throughout the year. Nothing further has been published, but careful studies are being made of the habits and geographical distribution of the mosquitoes of the genus *Anopheles*, which have been shown to be the sole conveyers of malaria, and of the mosquito known as *Stegomyia fasciata*, shown to be the conveyer of yellow fever.

WORK ON INSECTS INJURIOUS TO SHADE TREES.

Much work on insects of this class has been carried on during the year, and especially during the spring and early summer of 1903. Shade-tree insects were particularly abundant and destructive during this period, and opportunities for remedial work were more frequent than usual. The preparation of an extensive bulletin on the principal shade-tree insects is still under way. It is planned to keep this work on shade-tree insects separate from that of insects which affect forest trees, although to a certain extent they must overlap.

UNCLASSIFIED WORK ON INJURIOUS INSECTS.

An extensive investigation of the insects attacking the stems of growing wheat, rye, barley, and oats, not, however, including the Hessian fly, which has been dealt with in other publications of the Division, was carried on during the year, and a final report prepared by a special agent of the Division has been submitted for publication. The insects of the greatest economic value included in this investigation are the joint-worm flies and the wheat-straw worms. An investigation has been begun of the habits of and the best remedies to be used against the gadflies or horseflies of the family *Tabanidae*, which are so annoying to live stock, particularly in portions of the South. Further investigations have been made upon methods of control for certain insect enemies of mushrooms, and a further investigation of the insects affecting the seed of the clover plant has been begun. A report upon the insects affecting the cranberry was prepared by a special agent and is ready for publication. Investigations of the plantlice which injure grain have been carried on by one of the assistants, and an elaborate treatment of the bill bugs of the genus *Sphenophorus*, injurious to corn and certain grasses and grains, is in course of preparation. In the early part of the fiscal year an investigation was made by one of the scientific assistants of an outbreak of an injurious locust (*Camnula pellucida*) in Idaho, and remedial advice was given which proved of value to the agricultural population of that region.

WORK ON THE GEOGRAPHICAL DISTRIBUTION OF INJURIOUS INSECTS.

This work, which has been carried on now for a number of years, has been continued during the fiscal year, and the records are now becoming so numerous that they begin to afford an excellent indication of not only the actual range of injurious species, but also indications as to their possible spread.

TECHNICAL WORK.

A certain amount of the time of the expert entomologists in the employ of the office is devoted to technical work, monographing groups of insects of economic importance, and especially in the way of determination of specimens sent in by the experiment-station entomologists and others who have not access to large collections either of specimens or of books. Several technical bulletins are under way, and these are intended for the use largely of the entomologists of the State agricultural experiment stations.

BIBLIOGRAPHICAL WORK.

Work on the Bibliography of Economic Entomology is being thoroughly kept up to date. Material is at hand for the publication of a supplementary part No. VIII of the series of bibliographies of economic entomology formerly published (down to January 1, 1900) under a joint resolution of Congress passed in 1882. The Department is informed that this joint resolution no longer holds as authority for printing this bibliography, but it is hoped that it will be continued from the printing fund of the Department.

CORRESPONDENCE.

With the increasing growth of the Division and increasing appreciation of its value by the agricultural population, its correspondence has naturally greatly increased. During the year more than 8,000 letters have been written in answer to requests for information, and many hundreds of additional requests have been answered by means of circulars.

PROPOSED WORK FOR THE FISCAL YEAR 1904.

The work for the fiscal year 1904, which at the date of this writing is already well under way, will be carried on in the same directions as the work during the past fiscal year. Most of the investigations described in the foregoing pages are still being carried on. The investigation of the codling moth in the Northwest has been completed. The work against the Mexican cotton boll-weevil in Texas will be carried on during the whole of the fiscal year. An additional field assistant has been appointed, and \$30,000 will be expended in this work on cotton insects. The Department has by contract with the owners established seven experimental stations—one at Victoria, one at San Antonio, one at Austin, one at Calvert, one at Alford, one at Hetty, and one at Wharton. The station at Victoria has been supplied with a well-equipped laboratory. The sum first mentioned will not be entirely devoted to the Mexican cotton boll-weevil, since in the wording of the appropriation clause the cotton boll-worm was included. A special agent has been appointed who will devote the whole fiscal year to the

study of the latter insect, being stationed in Texas for most of the time. The possible spread of the cotton boll-weevil to other cotton States will be carefully watched and considered, and the recent occurrence of the insect in the experimental cotton plantation near New Orleans, La., is an indication of the fact that this investigation must be continued for some time to come, and that a strong effort must be made to prove to the cotton planters of the South that by cultural methods cotton may be grown in spite of the weevil. Investigations made early in the season show that the cotton boll-weevil exists in Cuba, and that it has probably always existed in that island. This point is an important one and renders commercial relations between Cuba and our Gulf ports an element of some danger to the cotton industry.

The work with insects from abroad will be continued, and special efforts will be made to breed and distribute the Chinese ladybird enemy of the San Jose scale.

In the forest insect investigations there will be great activity. The entomologist in charge of this branch of the work, with skilled assistants, will continue the observation and experiment stations mentioned in the preceding pages, and results of great value are to be expected from this work.

In silk culture the reeling work will be carried on at the Department, and as much of the cocoon crop of the calendar year as can be purchased will be reeled into commercial raw silk. More eggs will be imported from Europe and mulberry cuttings as well, and in the spring of 1904 a further distribution of eggs, mulberry cuttings, and seed will be made.

The work in apiculture and in the other branches of research will be continued.

PLANS RECOMMENDED FOR THE FISCAL YEAR ENDING JUNE 30, 1905.

By the organization of the work in entomology of the Department of Agriculture on the lines of a bureau, as indicated for this year, it is expected to very largely extend and develop the practical work being done in the study of injurious insects. The work of this Division has grown very rapidly during the last few years, but is capable of very much greater development. An organization on the lines of a bureau is already in practical operation, the work of the office being divided into a number of distinct departments, in various instances receiving specific appropriations. The plan of the new organization indicates the subdivision of the work in entomology which it has been decided to make. Many important fields of investigation have remained unworked in the past for lack of funds and expert assistance. If the plans made for the bureau organization meet with approval and receive the sanction of Congress, it is proposed to prosecute work over the whole field of applied entomology in America, as described under the different sections of the classification recommended.

ORGANIZATION OF WORK IN PROPOSED BUREAU OF ENTOMOLOGY.

The following is the plan of organization of work in the proposed Bureau of Entomology:

Field crop insect investigations:

- (a) Southern section—cotton, tobacco, sugar cane, rice.
- (b) Northern section—cereals and forage plants.

Fruit insect investigations:

(a) Northern section—orchard fruits, deciduous.

(b) Southern section—citrous and other tropical fruits.

Small fruit and truck crop insect investigations.

Forest and forest product insect investigations.

Insecticide and insecticide machinery investigations:

(a) Section of field operations and experiments.

(b) Section of chemical analyses and tests.

Investigations of insects affecting stored products.

Investigations of insects in relation to disease of man and other animals, and as animal parasites.

Special insect investigations—miscellaneous work:

(a) Section for the investigation and introduction of beneficial insects, and quarantine work.

(b) Section for fungous and other diseases of insects.

(c) Section for special insect investigations—emergency work and unclassified.

Insect laboratory, collections, and experimental garden.

Apicultural investigations.

Sericultural investigations.

Librarian and bibliographer.

FIELD CROP INSECT INVESTIGATIONS.

It is proposed to make two sections for this work:

(a) A southern section will have special charge of the insect enemies of cotton, tobacco, sugar cane, and rice, and will include the work now being done under the specific boll-weevil appropriation. The boll-weevil work will be carried on in the same general lines now in progress for 1904. The agents engaged in the cotton boll-weevil work can, however, from time to time, make studies and achieve valuable results with other insect enemies of cotton, and also of the other southern staples mentioned.

(b) A northern section will be devoted to the study of insect enemies of cereals and forage plants, a field of the greatest importance, which heretofore we have been able to cover only in a very fragmentary way by the occasional employment of special field agents to make investigations of particular insect pests of such plants. We hope to employ an expert investigator who shall devote his entire time to this field of inquiry, and to equip him with sufficient assistants and funds to carry out desirable investigations.

FRUIT INSECT INVESTIGATIONS.

Two sections are recommended for this field of inquiry:

(a) A northern section relating to the deciduous orchard fruits, which shall include such work as that done in the Northwest on the codling moth, and in addition work on all the other insect enemies of the apple, as well as the other deciduous fruits of America.

(b) A southern section devoted to the study of the insect enemies of citrous and other tropical fruits. This last field, formerly a very important one in the entomological work of the Department, has been practically neglected for several years, with the exception of the investigations made in California by Mr. Marlatt in 1900. It is desired to have a capable expert take charge of a continuous investigation of the insect enemies of all subtropical and tropical fruits, and give such direction and superintendence to work in the new tropical possessions as shall be required of this office. The importance of the subjects warrants the devotion of a sufficient sum to this work to enable prac-

tical field investigations to be made and to permit the publication of the results in the form of bulletins and circulars.

SMALL FRUIT AND TRUCK CROP INSECT INVESTIGATIONS.

This field of investigation has been actively covered in the past by this office, but it is possible to very much extend the work by placing it more directly under the control of the present expert in charge, and make it possible, by the establishment of larger experimental grounds, to carry out the investigations systematically and over the entire field. Among the special subjects on which investigations will have to be made in the near future are the insects injuriously affecting the sugar beet, a work that is necessary on account of the rapidly growing importance of this industry.

It is intended during the year 1905 to complete investigations which have already been carried on for a number of years on certain of the most destructive and troublesome insects affecting small fruits, particularly strawberries, blackberries, raspberries, and some similar crops.

FOREST AND FOREST PRODUCT INSECT INVESTIGATIONS.

These investigations have already been established as a separate section, working in cooperation with the Bureau of Forestry. In the new organization it is hoped to add to its efficiency by arranging for an additional field assistant and for an office assistant. The work outlined for 1904 will be continued, and special new work for the year will be taken up in the study of the oak and spruce insects with the view of publishing reports toward the close of the year. Any exceptional insect outbreaks in forest areas will be subject to prompt investigation.

INSECTICIDE AND INSECTICIDE MACHINERY INVESTIGATIONS.

It is proposed that this section shall cover the entire field of practical experimentation with insecticides and insecticide machinery. The detail of a chemist from the Bureau of Chemistry, to take charge of the analyses and tests, is planned, and it is proposed to provide an expert to work in cooperation with the chemist to carry out the field operations and experiments on growing trees and vegetables. The enormous increase in the employment of insecticides in the last few years calls for very much more extensive investigation on the part of this Department than it has hitherto been possible to give to the subject. The very great use of petroleum oils especially demands a constant supervision of the oil products used for insecticides, some of which are very injurious to plants and others harmless. The demand for a thorough investigation of this field by the Department of Agriculture is voiced by the resolutions recently passed at the meetings of the Society for the Promotion of Agricultural Science and of the Association of Economic Entomologists. The proposed change will bring all the insecticide investigations of the Department under one office and facilitate and give a much more practical bearing to the work than has been heretofore possible.

INVESTIGATIONS OF INSECTS AFFECTING STORED PRODUCTS.

A good deal of work has already been done under this head, but it is proposed, by making this a special section, to very much extend

the work and give it a more practical bearing, undertaking experiments to determine in a practical way, in granaries and large warehouses, mills, and other establishments, the value of the means of protecting stored products. It is proposed in this section to include the study of the insect enemies of preserved animal and vegetable food substances, as well as the cereal products, and also materials and fabrics of all sorts.

INVESTIGATIONS OF INSECTS IN RELATION TO DISEASES OF MAN AND ANIMALS, AND AS ANIMAL PARASITES.

It is wished to very much extend the considerable work already done in this field. For this purpose it is proposed to establish for it a special section. It will include, in the case of the domestic animals, all of the internal parasitic flies, the external parasitic insects, and the biting flies, such as the horn fly, gadflies, buffalo gnats, etc.: in the case of man and animals the important rôle of insects as conveyers and disseminators of disease. A very capable assistant will be required to take direct charge of this work.

SPECIAL INVESTIGATIONS.

Under this head is classified the investigation and introduction of foreign beneficial insects, a subject which has assumed in recent years very great importance. The supervision of quarantine operations will also come in this section, as well as the propagation and distribution of fungous diseases of insects and the general investigation of this important subject. For this work it will be necessary to secure the services of two high-grade experts, one to have charge of insect introductions and quarantine, and the other to be an expert pathologist. Relative to the last, it may be said that this office has been able to carry out its work with insect diseases only through the courtesy and with the material aid of the Bureau of Animal Industry and experts in other offices of this Department. This work is of sufficient importance to demand the appointment of an expert who shall be able to devote all his time to the subject. The artificial use of contagious insect diseases to control insect pests is a field which is constantly demanding investigation, and its importance, perhaps, is much greater than has been hitherto realized.

INSECT LABORATORY AND EXPERIMENTAL GARDEN.

A small and very inadequate experimental garden is now attached to the insectary of this Department. It is proposed to secure a larger tract for the establishment of an experimental orchard and garden in connection with the Washington office to facilitate and give a practical feature to the local breeding and insecticide operations. This will necessitate the employment of a gardener and laborer.

APICULTURAL INVESTIGATIONS.

In apiculture it is proposed to specially investigate the subject of artificial pasturage, which hitherto has not received the attention it deserves. A series of experiments will be entered upon to determine what crops may be profitably employed to fill the gaps in the honey

yield, or to create artificial pasturage for apiaries, and an effort will be made in this connection to introduce honey plants from abroad. It is proposed to import and test various races or species of bees that are now little or not at all known in this country; for example, the race native to the Caucasus and those found in Dalmatia, Austria, and notably the large bee of the East (*Apis dorsata*), to be obtained from the Philippine Islands. The breeding of crosses will be continued, and the collection of statistics is proposed. Further, it is especially desired to undertake experimental and remedial work with the diseases of bees; and particularly with an obscure disease which has been playing havoc with certain apiaries in the State of New York.

SERICULTURAL INVESTIGATIONS.

It is desired to make this a special section of the entomological work of the Department. To carry out the investigations increased appropriations are desired. For the year 1905 it is the intention to follow up the work outlined for the year 1904; to establish and equip experimental stations in the South; to enter into cooperative work in silk raising with some of the agricultural experiment stations which have expressed the wish to assist us in the investigation of silk culture; to increase the size of the reeling plant in Washington, so that more cocoons can be reeled, and so that instruction can be given.

U. S. DEPARTMENT OF AGRICULTURE.

REPORT

OF

THE ENTOMOLOGIST

FOR

1906.

BY

L. O. HOWARD.

[FROM ANNUAL REPORTS, DEPARTMENT OF AGRICULTURE.]



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REPORT OF THE ENTOMOLOGIST.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., August 23, 1906.

SIR: I submit herewith an executive report covering the work of the Bureau of Entomology for the fiscal year ending June 30, 1906, dividing it, in accordance with your instructions, into the following headings:

(1) A review of the operations carried on during the fiscal year 1906.

(2) An outline of the plans proposed for the work of the Bureau for the fiscal year 1907 under appropriations already made for that year.

(3) Suggestions as to work recommended for the fiscal year ending June 30, 1908, for use in preparing estimates.

Respectfully,

L. O. HOWARD,
Entomologist and Chief of Bureau.

HON. JAMES WILSON, *Secretary.*

WORK OF THE YEAR.

The work of the Bureau during the year beginning July 1, 1905, and ending June 30, 1906, may be classified as follows:

- (1) Work on the Mexican cotton boll weevil.
- (2) Work on the cotton bollworm.
- (3) Work on other cotton insects.
- (4) Importations of useful insects.
- (5) Investigations of insects damaging forests.
- (6) Investigations of insects damaging deciduous fruit trees.
- (7) Field-crop insect investigations.
- (8) Work on insects injurious to vegetable crops.
- (9) Investigations of insects in their direct relation to the health of man and domestic animals.
- (10) Work on scale insects.
- (11) Work on insects injurious to stored products.
- (12) Experimental work with insecticides.
- (13) Work in bee culture.
- (14) Work in silk culture.
- (15) Miscellaneous investigations and other work.

WORK ON THE MEXICAN COTTON BOLL WEEVIL.

The boll weevil investigations have been under the immediate charge of Mr. W. D. Hunter.

GENERAL STATUS OF THE PEST.

The growing season of 1904 was remarkable on account of the comparative scarcity of the boll weevil. At many points the reduction was so great as to give rise to the belief that it had been exterminated or had emigrated to other regions. The causes of this comparative scarcity are complicated. The climatic conditions in the summer and fall of 1904, together with the work of the cotton caterpillar, greatly reduced the number of hibernating insects in the winter of 1904-5; then occurred a long, cold, and wet winter, the most unfavorable winter to the weevil since the insect has been in Texas. Owing to these conditions, some of the area that became infested late in the season of 1904 was entirely void of weevils in the early part of 1905, but the fall movements of the weevil in 1905 more than covered this area. Opportunities were therefore given in the fiscal year 1906 for studies for which there had been previously but little opportunity, and many points that have a bearing upon the possibility of the continued advance of the pest were investigated.

EXPERIMENTAL FARMS.

The value of experimental field work in its final analysis depends very largely upon the number of seasons thru which it has been carried and upon the variability of these seasons. In the case of the boll weevil the insect is constantly advancing into new regions, and is constantly confronting new conditions to which it must adapt itself. For these reasons, during the fiscal year 1906 the Bureau continued experimental field work at fourteen places in Texas and two in Louisiana. The aggregate acreage which was placed under contract in these experiments was 877. On these places, which in most cases have been under observation for several years, the modifications in the cultural system of mitigating damage, made necessary by the changing habits of the insect, were carefully studied. This work, of course, is intimately connected with the work carried on in the laboratory. The experimental fields were located in Anderson, Bexar, Dallas, Karnes, Kaufman, Limestone, Navarro, Robertson, Travis, Victoria, Wharton, and Williamson counties, Tex., and De Soto and Vernon parishes, La. The same form of contract was used as in previous years, and the total cost to the Bureau of the complete charge of the cotton grown was less than \$2,500.

OTHER FIELD WORK.

In addition to these large-scale experimental plats, numerous experiments were conducted having a bearing on the practical control of the weevil. In one locality an area was found exactly suitable for an extended experiment in the hand picking of the infested bolls. Similar experiments had been tried before, but never under such favorable circumstances. Further tests in the field were made

with Paris green and other poisons in order to check the results of former work. This was deemed necessary on account of the very great importance that has been placed by different people on the possibility of poisoning the boll weevil. An extensive canvass of the State was made to find farmers who had followed the practise of fall destruction of the plants and other recommendations of the Bureau, and their experiments have been collected and tabulated. An especial study has been given the question of the occurrence of volunteer cotton, on account of the important effect which its presence has upon the damage done by the weevil. At the same time many observations have been made to determine the effect of direct sunshine for destroying the pest. Moreover, the continued spread of the weevil has been watched carefully, and publications regarding the new territory infested have been issued in cooperation with the Weather Bureau when deemed desirable.

The Bureau has also withheld a fund to be used if the eradication of isolated colonies should become advisable. There is still danger that outbreaks of this kind will be found far beyond the principal infested region. Whenever a discovery of this kind shall be made the Bureau is ready to attempt the destruction of the local colony. It is possible that in this way the advance of the insect can be considerably retarded.

A careful study has been made of the conditions in western Texas, in order to determine whether the weevil will be likely to spread to that part of the State in spite of the prevalent supposition that such spread will not take place.

LABORATORY WORK.

In the main laboratory at Dallas, Tex., much work was done in continuation of experiments already started, but at the same time a number of new lines of work were instituted. In the breeding cages experiments were carried on to determine the effect of different temperatures and condition of food supply upon the development of the weevil. The breeding of parasites was continued, and an especial study was made of a native ant (*Solenopsis geminata*), which seems to be becoming more and more an important factor in the natural control of the weevil. This ant has long been known as the important enemy of the leaf worm of cotton, and is generally distributed thruout the cotton-growing area. It feeds upon nectar as well as upon animal food. Examinations of several thousand squares collected from different localities in Texas showed that this ant destroyed at times as much as 50 per cent of the weevils. The proportion destroyed varied according to the conditions which are favorable for the work of the ant. The adult weevil is not attacked, but the immature stages, and especially full-grown larvæ and pupæ, are most abundantly destroyed. Frequently the ants enter squares which are still hanging upon the plants, but as a general rule entrance is made only after the square has fallen to the ground. Certain points concerning the distribution of this ant, its adaptability to different soil conditions, and the possibility of its artificial propagation, have been studied. In many localities it is certainly the most important natural factor in the control of the weevil, and seems to be becoming more effective.

In connection with the laboratory work, especial studies were made in areas of great weevil abundance and scarcity, in order to determine if possible the reasons for these conditions.

An especial laboratory study was made of the growth in the cotton square or boll known as proliferation, which more or less frequently destroys the weevil. The results of this study show exactly in what ways proliferation affects the insect, and it is hoped that it will furnish a basis for work that may be done by the plant breeders of the Bureau of Plant Industry. Many new features were discovered, and the subject is treated in a bulletin about to be issued.

TRUE PARASITES OF THE BOLL WEEVIL.

For many years after the weevil came into Texas it was found that parasites had but little effect upon it. It has recently been ascertained, however, by agents connected with this investigation that in the Brownsville neighborhood at least 50 per cent of the early stages are sometimes destroyed by parasites. In order to ascertain whether it is possible to assist the work of these beneficial insects, an extensive series of experiments and observations has been undertaken in the laboratory. This work divides itself into two branches: (1) An investigation of the possibility of introducing from the North parasites of insects related to the boll weevil, and (2) an investigation of parasites of southern insects related to the boll weevil. A suitable case for transporting parasites has been devised, and much information has been obtained that may have a practical bearing. An instance of this is that the squares which remain hanging upon the plants have been found invariably to show the highest percentage of parasitism. In this discovery is a valuable suggestion for the experts who are engaged in obtaining suitable varieties of cotton for planting in weevil-infested regions. A number of instances of the effective work of parasites on cotton insects other than the boll weevil are well known. In one case the destruction of over 95 per cent of the eggs of the cotton leaf worm by an egg parasite has been noticed. The cotton-square borer (*Uranotes melinus*) is parasitized to such an extent that only one or two, instead of several broods, as would be normal, are allowed to mature in a season. With such analogies and the known success which has attended similar experiments, it is considered that the work relating to parasites of the boll weevil is of the utmost importance. That small results have been gained from the work of parasites up to this time is largely due to the recent invasion of the cotton fields of the South by the insect.

HIbernATION EXPERIMENTS.

The most important hibernation work which has been undertaken is referred to in a succeeding paragraph, under the head of "Cooperation with the Louisiana crop pest commission." In addition to that work, however, during the fiscal year 1906 much has been done in Texas and especial attention has been given to determining the maximum time which the weevils can live without cotton. Aside from the 25,000 weevils utilized in the work at Keatchie, La., 15,000 have been utilized in the work in Texas, 11,000 of which were placed in cages at Dallas, where different conditions for hibernation were

arranged. At Victoria another large number of weevils were tested in a similar way, and at Calvert (an intermediate point) still others were used. In addition to the field conditions under which some of these weevils were placed, others were placed in different substances, such as cotton seed, in order to determine the likelihood of their being conveyed in various materials into which they might make their way during their late summer and fall dispersion. This work relative to hibernation will lead to a detailed report on the subject to be issued during the fiscal year 1907.

COOPERATION WITH THE LOUISIANA CROP PEST COMMISSION.

The cooperation between the Bureau of Entomology and the Louisiana crop pest commission, which was begun in 1904, when Prof. H. A. Morgan was secretary of the commission, was continued along similar lines during the fiscal year 1906, with Mr. Wilmon Newell, who became secretary in February, 1905. Provision was made for the payment of three entomologists who reported jointly to the secretary of the crop pest commission and to Mr. Hunter, the agent in charge of the boll weevil investigation of the Bureau. During the season of 1905 it was planned to enter upon an extensive study of the so-called migratory movement of the boll weevil on account of the possibility of learning some method of checking further advances or at least of learning the approximate time when other regions may become infested. Unfortunately, on account of the occurrence of yellow fever in Louisiana in the summer of 1905 and the consequent rigid quarantine, it was impossible to carry on this work as planned. Nevertheless, when the quarantine was lifted in November a number of important observations were made.

In cooperation with the Louisiana commission, it was possible for the Bureau to undertake a most extensive series of experiments relating to the hibernation of the weevil. For some years we have been accumulating data regarding the hibernation of the weevil, but the great importance of complete knowledge made it necessary that still more extended work should be begun. In the fall of 1905 more than 25,000 weevils were placed in large cages constructed by the Louisiana commission at Keatchie; 17,600 were collected in Texas and the remainder in Louisiana. In different cages attempts were made to reproduce the various conditions that may be found in cotton fields in the South. Some cages were left with the cotton standing, and in others everything was removed; in others trash, such as moss and logs, as well as cotton seed, was placed. The 18 large cages together gave an opportunity of reproducing a very great variety of conditions. The records of daily emergence of weevils in these cages has been carefully kept. The information obtained will result in the completion of our knowledge as to how the weevils pass the winter, which has hitherto been incomplete.

WORK ON THE COTTON BOLLWORM.

The work on this insect during the fiscal year was largely in the character of demonstrations indicating the value of conclusions already reached and detailed in the last annual report of the Bureau. Unlike the boll weevil, the bollworm has existed for such a long

period in this country that no apparent process of adaptation or change of habits is going on. In consequence it has been considered unnecessary to continue the technical work on the life history of the pest. The demonstration work was carried on upon 120 acres of cotton in Hunt and Kaufman counties in Texas, and in the Chickasaw Nation in the Indian Territory. In addition to this work, which was done under contract, some successful efforts were made in the local extermination of the bollworm by means of poisons.

WORK ON OTHER COTTON INSECTS.

While incidentally more or less work on other insects injurious to cotton has been done by the force employed in the cotton boll weevil investigations, the bulk of the work in this direction has been done under cooperation with the Texas State Agricultural Experiment Station, at College Station, Tex. An agent of the Bureau has been stationed at the college to devote his attention to some studies of the minor insects of the cotton belt. A very important discovery has been made in connection with these studies, in propagating the predaceous enemies of a plant louse (*Aphis gossypii*), which sometimes causes great damage to young cotton. These predaceous enemies are ladybirds of the family Coccinellidæ, and it has been shown that where they can be started in their work a few weeks earlier than they normally appear the injury by the plant louse will be greatly reduced. Following this suggestion, a very large number of specimens of the various species of ladybirds were carried thru the winter, and in at least one instance their introduction into a seriously damaged field resulted in a very short time in the practically complete eradication of the plant louse. It is believed that this work will lead to a practicable method of controlling a pest which causes very considerable damage to cotton.

IMPORTATIONS OF USEFUL INSECTS.

The especial lines of work and new introductions which were detailed in the last report of the Bureau have been actively continued. By far the greatest importations of the year have been of parasites and predaceous enemies of the gipsy and brown-tail moths, in cooperation with the officials of the State of Massachusetts, as described below. Some new introductions have been planned relating to fruit insects, and notably the codling moth, and an effort will be made to introduce parasites of the latter insect from France and other European countries the present summer and autumn. The experiments with the kelep or boll weevil ant from Guatemala and the various enemies of scale insects have been under way during the year.

It is possible in many instances to secure the sending of beneficial insects by the official entomologists of other countries without expense to the Department, as was done notably in the case of the introduction of *Scutellista cyanea*, the important enemy of the black scale, from the government of Cape Colony, South Africa. In return for such services and as an earnest for possible future courtesies of the same sort exportations of parasitic and predatory insects have been made from this country, under the auspices of the Bureau, to foreign countries. A notable instance has taken place during the fiscal year.

Diaspis pentagona, a scale insect which occurs more or less abundantly upon various fruit trees in portions of the United States, is a serious enemy to the mulberry tree in Italy, and therefore sendings in large quantity of parasitized scales of this species have been shipped to Dr. Antonio Berlese, the head of the Royal Station for Agricultural Entomology at Florence, Italy. After arrival two species of parasites were bred, namely, *Prospalta murtfeldtii* How. and *P. berlesei* How. Attempts have been made to colonize these parasites in Lombardy in the hope that they will prove effective aids in the reduction of the mulberry scale.

INTRODUCTION OF THE NATURAL ENEMIES OF THE GIPSY MOTH AND THE BROWN-TAIL MOTH.

In the last report an account was given of the work undertaken in cooperation with the State of Massachusetts in the introduction of the European parasites of these two extremely injurious insects, whose threatened spread beyond the borders of the New England States is at present a matter of lively concern to the fruit and forest interests of the United States. It was shown that by the cooperation of the official entomologists in European countries and by agents engaged by the Chief of the Bureau during a European trip in June and July, 1905, many hundreds of parasitized larvæ and pupæ of the gipsy moth from various parts of Europe were sent to Boston and held for the propagation of parasites.

Prior to the beginning of this undertaking it was supposed that the entire work would be done in this way, and that the simple sending from Europe to Boston of parasitized full-grown larvæ and pupæ of both of the injurious insects and the subsequent propagation and distribution of the parasites in and from a well-equipped laboratory would be the speediest and easiest method of accomplishing the desired results, but as the investigation proceeded it was found, in spite of a total silence on this point in European records, that the newly hatched larvæ of the brown-tail moth, passing the winter as they do in great numbers surrounded in mass by silken webs and spun-in leaves, are also parasitized. It was further found, also, that the eggs of both the gipsy moth and the brown-tail moth contain parasites in parts of Europe. Therefore arrangements were at once made to enlarge the scope of the sendings and to secure the importation from Europe of large numbers of the over-wintering nests of the brown-tail moth during the autumn of 1905 and the winter of 1905-6 and of the egg masses of both species at a later date. In the meantime a house well situated for laboratory purposes was rented by the superintendent for suppressing the gipsy and brown-tail moths for the State of Massachusetts, Mr. A. H. Kirkland, in the town of North Saugus, in a locality well surrounded by forest growth abundantly infested by both species; and a trained assistant was put in charge. About 150 breeding cages were constructed, and arrangements were made for the erection of large screened structures over infested trees in the woods.

During the winter 117,257 nests of the brown-tail moth were received from 33 localities in Europe, ranging from North Germany south to Hungary and west to Brittany, and comprizing a large range of varying elevations and climatic conditions. Only a small number

of parasites were reared from the majority of these localities, but very satisfactory numbers, amounting to 70,000, were reared altogether, the largest numbers coming from 12 different localities. Of the 70,000 parasites reared, it is safe to say that about 8 per cent were hyperparasites—that is, parasites upon parasites. By the time the parasites began issuing from these nests an expert of the Bureau, Mr. E. S. G. Titus, had been placed in charge, and by means of the specially constructed breeding cages it was a comparatively easy matter for this expert to separate the hyperparasites from the true primary parasites and to destroy the former. There were three species in particular which promised good results, namely, one which for the present must be called *Pteromalus processioneæ* Ratz. and another undetermined species of the same genus, together with *Habrobracon brevicornis* Wesm. They began to appear about April 25 and continued to issue until about June 15. With the cooperation of Mr. Kirkland, a number of localities were found in which there was slight danger of forest fire and in which no work against the moths would be undertaken for at least some months to come, and colonies of various sizes—the three principal ones including, respectively, 10,000, 15,000, and 25,000 parasites—were liberated in the open. At the same time much smaller colonies were placed in the large breeding tents mentioned above. Both the outdoor cage experiments and the open experiments were seriously hampered from the fact that the season proved to be one of extraordinary humidity, from which fact a fungous disease appeared and destroyed a large proportion of the brown-tail moth larvæ in the vicinity of Boston. Nevertheless all three species were seen to lay their eggs in American-born caterpillars, and there is positive proof of the development of at least one generation on American soil of the first-named parasite.

Altho these parasites were reared from the extremely small overwintering larvæ of the brown-tail moth, they did not hesitate, on issuing in the spring and early summer, to lay their eggs upon the larger American-born larvæ. Later in the season they were seen laying their eggs in full-grown larvæ of the brown-tail moth and in the pupæ of the gipsy moth.

Analyzing the quantitative rearing of the parasites, it was found that a definite percentage (larger in some localities and smaller in others) of the overwintering larvæ of the brown-tail moth are destroyed by parasites which affect the later stages of growth as well as other related lepidopterous larvæ. The parasites thus have an extremely early start in the season in very large numbers, rendering the subsequent destruction of the injurious caterpillars much more certain than had the parasites past the winter in an inactive condition.

During the winter, also, efforts were made to import, in the wintering conditions, the two large European ground beetles, *Calosoma sycophanta* and *Calosoma inquisitor*, well known as important European enemies of both of the injurious caterpillars. No success in importing living specimens was gained until March, 1906. From that time on until July 20 small consignments of living adult beetles were received, together with many specimens which died upon the journey. In all 690 living specimens of *C. sycophanta* and 172 of *C. inquisitor* arrived at Boston alive, some of them dying soon after arrival. Colonies were started in various localities about Boston,

including the towns of Winchester, Burlington, Malden, Lynnfield, and Saugus, and in these were placed 360 of the former species and 110 of the latter. Others were kept in cages, and were noticed to feed very heartily, traveling all over the cage and tree searching for and capturing larvæ and other soft-bodied insects. In the open localities the beetles were occasionally seen. Young larvæ were first seen June 17, and early in July nearly full-grown larvæ of the *Calosomas* were found feeding upon both brown-tail and gipsy moth caterpillars.

In the summer of 1906, beginning with June 7 and continuing until late in the season, larvæ and pupæ of both the gipsy moth and the brown-tail moth were received in considerable numbers from many European localities, the general regions being about the same included in the winter nests of the brown-tail moth sendings. From these a large number of parasites of several different species have been reared, the most abundant having been tachina flies, the percentage of parasitism in some instances having been very great. In lots received from Hungary and from Holland the percentage of parasitism was 100, every gipsy moth caterpillar having been destroyed by its parasite. From the brown-tail moth shipments 1,404 tachina flies have issued, and have been colonized, and 653 puparia are still on hand that will probably over-winter. From the gipsy moth shipments 1,363 parasitic flies of twelve species have been bred, and there are still on hand 3,371 puparia from which the flies may issue next spring. Eighteen out-of-doors colonies were planted, covering practically all of the generally infested regions in the State of Massachusetts, and there is evidence already that a generation of two species has been reared on American soil under perfectly natural conditions, and three additional species have been reared thru one generation in the out-of-doors cages—two of them from both gipsy moth and brown-tail moth pupæ and one from gipsy moth pupæ alone. One of the European species has shown a readiness to live upon the native fall webworm and may go thru another generation the present summer.

From egg masses of the brown-tail moth received from Europe in midsummer two species of European parasites have been reared and have been noticed laying their eggs in American eggs of this insect.

Thus the outlook for the success of these large-scale importations is good. The greatest care has been taken to prevent the introduction of hyperparasites and other injurious insects, and there seems reason to suppose that sooner or later the complete natural environment of both of the injurious species will be established. This will mean, if it eventually comes about, that the American conditions in relation to both gipsy moth and brown-tail moth will be placed on a par with European conditions and that these insects will cease to occupy their present position as pests of prime importance.

NEW COCCINELLIDS FROM EUROPE.

During the late winter months and the spring of 1906 several species of European ladybirds of the family Coccinellidæ, well known as destroyers of plant lice, scale insects, and small soft-bodied insects of other groups, have been imported from Germany, France,

and Austria. Four of these species were received in sufficient numbers to warrant some hope of their establishment in this country. These are *Adalia bipunctata*, *Halysia 14-punctata*, *Exochomus quadripustulatus*, and *Coccinella septempunctata*. All of these insects were liberated in the open in the vicinity of the parasite laboratory at North Saugus, Mass. The country about contains orchards and forests, together with an occasional vegetable garden, and it is hoped that the species will increase sufficiently so that it will be possible to capture at any time specimens for distribution to other parts of the country where destructive outbreaks of plant lice or other insects upon which they will prey may occur.

THE KELEP OR GUATEMALAN ANT ENEMY OF THE COTTON BOLL WEEVIL.

In the report of last year was recorded the failure to over-winter successfully in Texas of the first colonies of the kelep imported, the explanation suggested by Mr. O. F. Cook, who has this work in charge, being that the colonies were undersized and that their location in Texas was in many cases unfortunate, being in improper soils without adequate drainage. To give further and more satisfactory test, 150 full-sized colonies were introduced into Texas from Guatemala during the fiscal year ending June 30, 1905, and were located at several points and in a variety of soils with especial care as to adequate drainage. More recent importations from Guatemala have suffered from delays en route, owing to restrictions of steamship communications by the New Orleans yellow-fever quarantine. Unfortunately, even the selection of the most favorable localities failed to result in the successful over-wintering of this beneficial ant during the winter of 1905-6, and all of the out-of-door colonies perished. A possible useful rôle for this insect in Texas is therefore seemingly out of the question. There seems to be no doubt, from Professor Cook's observations in Guatemala, of the beneficial action of this ant in the small garden cultures of cotton in the high mountain districts of Alta Vera Paz; and it has during the year been discovered in more accessible localities. It is possible that the insect may have some economic value in some of our subtropical possessions, where the winters will be less rigorous and the climate more suitable than in Texas.

OLDER IMPORTATIONS.

The various older importations of predaceous and parasitic insects, which have been referred to in the annual reports of the last few years, have been under observation during the last fiscal year, and maintained substantially the same status. This applies to the Asiatic-ladybird enemy of the San Jose scale (*Chilocorus similis*) and the black scale parasite (*Scutellista cyanea*) as well as the older and better-known predaceous enemies of scale pests of citrus and other plants in California.

INVESTIGATIONS OF INSECTS DAMAGING FORESTS.

The investigations of insects damaging forests have progressed in a satisfactory manner under the leadership of Dr. A. D. Hopkins, special agent in charge of Forest Insect Investigations. Numerous

problems have been studied, and a large store of general information upon forest insects has been accumulated.

Altho, from an administrative standpoint, this work is carried on independently of the Forest Service of the Department, the intimate cooperation of the previous year has been continued, especially as regards the investigation of insects injurious to forests in the national reserves. Many specimens of such insects and their work, as well as valuable notes, have been sent in by officers of the Forest Service. The cooperation of the Forest Service has also been of assistance in the investigation of the locust borer and of the white-pine weevil.

As heretofore, investigations have principally been conducted in the field during spring, summer, and fall, while the winter months have been devoted to the classification and arrangement of collections, the working over of notes, and the preparation of the more important results for publication, all of the members of the field force returning to Washington in the winter time for this purpose.

FIELD WORK.

During the year the greater part of the work has been conducted from field stations, as follows:

Kanawha field station, Kanawha Station, W. Va., by Doctor Hopkins.

Southern field station, Tryon, N. C., by Mr. W. F. Fiske.

Black Hills field station, Custer, S. Dak., and the Rocky Mountain field station, at Centerville, Idaho, by Mr. J. L. Webb.

The northwestern field station, Pialschie, Wash., and the California station, at Wawona, Cal., by Mr. H. E. Burke.

The location of these field stations has been determined by the peculiar advantages offered at those points for the study of some special problem or problems. In addition to the problems of primary importance, others less pressingly in need of solution have been worked upon by the field agent in charge whenever there has been favorable opportunity. Many of these problems have thus received attention from more than one member of the force, and upon some the work of all has been directed. Some of the more important of the investigations under way are as follows:

BLACK HILLS BEETLE.—The extension of the ravages of the Black Hills beetle into Colorado and the active interest displayed by certain persons in that State in their desire to check the advance of the insect called for a special investigation, which was undertaken in the fall of 1905. The results were in the highest degree satisfactory, and an account was published in Bulletin No. 56 of the Bureau. Recommendations are now being actively followed by private persons with excellent chances of checking what otherwise might be a most serious invasion. The present summer another investigation was made in June and additional facts determined which complete our knowledge of the life history of the insect within its range and bring about slightly different recommendations for its control at a great saving of time and expense over previous recommendations.

In the Black Hills the situation is not so encouraging. The recommendations of the Bureau, while effective in the portion of the

reserve where they were put into practise, could not be carried out thruout its extent. The result is that a large area of timber which was not injured at the time of the former investigation in 1901 has become badly infested, and much valuable timber has been killed. The importance of the recommendations of the Bureau was not at first realized by owners of property. Moreover, the legal restriction against the shipment of timber out of South Dakota was not promptly amended, and the necessary sale and disposal of infested timber had been delayed. Thus the lack of control of the beetle in the extension of its range is sufficiently explained. These difficulties have now been partially overcome. Especial provision was made in the agricultural appropriation bill for 1906 allowing the shipment of timber from the reserve until 1908, and certain funds have been appropriated for the purpose of carrying out the recommendations of the Bureau. The expenditure of this fund was begun in the spring of 1906, and in April an agent, Mr. Webb, was sent to the reserve to direct operations. The work was greatly hampered from the first by scarcity of labor and was suspended on June 14 on account of lack of funds without enough work having been accomplished to appreciably diminish the force of the next attack of beetles upon trees now healthy. Unless the Forest Service finds it possible to have a large percentage of the infested timber cut during the following fall, winter, and spring, the ravages of the insect will not be controlled.

An important result of this season's investigations has been to demonstrate that the mere peeling of infested trunks is sufficient to cause the destruction of the contained insects up to July, thus adding two months to the period during which this work can be economically carried on. A resident of the Black Hills has devised a tool by which it is possible to bark a considerable portion of the trunk of a tree still standing. By this operation it is hoped the timber may be preserved from decay for a longer period than when the trees are previously cut or when they are allowed to stand with the bark attached.

THE DESTRUCTIVE PINE BARKBEETLE.—The investigations by Mr. Fiske of the damage to pine and spruce forests in the Southern States by this insect were continued thruout the year, the results of the past two years largely confirmed, and some new facts of value ascertained. The results have been collected and will form the subject of a bulletin in the near future. Our knowledge of the insect is now very complete except as to its habits of migration, and since recommendations for its control must depend very largely upon this point, the investigation must be continued further. It is not more abundant now than usual in parts of the South where it normally occurs, but there is indication that during the present year it is extending its range farther to the north than it has recently.

INSECTS INJURIOUS TO FOREST PRODUCTS.—Investigations on this class of insects have been continued thruout the year, and considerable new information has been gained. Breeding experiments with several species have resulted in a more complete knowledge of their life history, and experiments which will serve as groundwork for more extended experiments in the future have been made with several insecticides. An important point has been gained in the determination of the seasons during which infestation of stored lumber is likely to

occur by the different species. An insect known as *Sinoxylon basilaris* has caused the destruction of large quantities of persimmon shuttle blocks in Georgia, and experiments have been made in the way of dipping the blocks in various solutions to prevent subsequent attack, with results that are satisfactory. The cerambycid borers of ash and hickory lumber have been studied, and the life history and habits of the more important species have been determined, together with the seasons of the year during which lumber is liable to infestation by each particular species. Already several lumbermen and millmen have reported good results following the recommendations of the Bureau.

INSECT ENEMIES OF FOREST REPRODUCTION.—Beetles of the genus *Pissodes* as enemies of forest reproduction have been studied in the most thorough manner possible, both in the field and in the laboratory. Experiments to determine the effect of systematic pruning of infested trees for the purpose of overcoming the evil effects following the attack of the white pine weevil have been carried on and the results achieved have been encouraging. It has been shown that injuries which might subsequently render the trunks of trees practically worthless may be remedied in this manner, provided the pruning is done within three years after the injury is sustained. By careful systematic work it has been found that the species infesting the terminal twigs of white pine is distinct from that which infests stumps and logs and which was formerly supposed to be identical with it. This is a very important point in connection with the control of the white pine weevil, which is undoubtedly the cause of more injury to the white pine in its natural range than all other insects put together. Another species attacking young Engelmann spruce in Idaho has been studied, and still another whose life history was previously unknown and which kills the young saplings of red fir and Douglas spruce has also been investigated. An account of these insects was published in the Yearbook of the Department for 1905.

THE WESTERN PINE-DESTROYING BARK-BEETLE.—In compliance with a request by Mr. Gifford Pinchot, Chief of the Forest Service, a preliminary investigation on the cause of the death of pine in the region north of Boise, Idaho, was made in the fall of 1904. This was followed by a special investigation in 1905 at the Rocky Mountain field station at Centerville, Idaho.

This beetle was found to be the principal enemy of the pine in that section, and an account of it, together with recommendations for its control, is now in press.

FOREST INSECTS OF THE PACIFIC SLOPE.—The study of the forest insects of the Pacific slope has been continued throughout the year by Mr. Burke at the field station at Pialschie, Wash., and during May and June at the Yosemite National Park at Wawona. Investigations have also been conducted at Summerdale and other localities in California and upon Mount Rainier in Washington. The main object of the work in Yosemite is to learn more concerning the unhealthy conditions of the forests in the National Park in order to form more comprehensive methods for the control of injurious insects. Several species of *Dendroctonus* are attacking the pine and are receiving especial attention, and a species of bark maggot has been

found seriously injuring the wood of the California white fir. A number of other insects of greater or less importance have been investigated.

NATURAL ENEMIES OF FOREST INSECTS.—A very extensive series of notes on the parasites and natural enemies of forest insects has been collected in connection with these investigations. The subject has not heretofore been considered as among those of primary importance, and it is perhaps too soon to attempt to utilize the fragmentary knowledge at present available. With increased insight into the habits and host relations of certain of the species new methods by which it might become possible to utilize their aid in a practical manner are continually suggested. As an example, it has recently been discovered that certain species of an important group of parasites which attack a variety of wood and bark boring larvæ may be bred with the greatest freedom in confinement. Their rate of multiplication under favorable circumstances is enormous, and by providing in advance a suitable supply of food it seems likely that very great numbers may be artificially propagated and conveyed to a distance. Experimental work in this direction will be undertaken.

OFFICE AND LABORATORY WORK.—The proper care of the rapidly growing collection of forest insects is becoming more and more difficult. Many of the species included are new to science, so that proper identification even of the economically important forms often means a technical revision of the genus or family. Much technical work has been done upon the bark-boring beetles of the family Scolytidæ, upon wood-boring Buprestidæ and Cerambycidæ, and upon other groups as well. The genus *Pissodes* has been revised.

INVESTIGATIONS OF INSECTS DAMAGING DECIDUOUS FRUIT TREES.

The work on deciduous-fruit insects, under the immediate charge of Mr. A. L. Quaintance, has been largely a continuation of that already in progress at the close of the fiscal year 1905, namely, investigation of the insects injuriously affecting the peach. Numerous other deciduous-fruit insects have been investigated as opportunity has offered at the field stations and in the laboratory at Washington, D. C. The field stations at Youngstown, N. Y., and at Fort Valley, Ga., were continued until the close of the growing season of 1905. In the spring of 1906 a southern field station was located at Myrtle, Ga., in the midst of a large peach acreage, and a northern field station was located at North East, Pa., in the extreme northwestern portion of the State, in which section there is a large fruit interest. May 1, 1906, a field station was established at Nebraska City, Nebr., for codling moth work.

SAN JOSE SCALE INVESTIGATIONS.

Aside from a limited investigation of the parasites of the San Jose scale and a test of the effect of various fertilizers and poisons applied to the roots of infested potted trees, work has been confined to a continuation of last year's experiments on the standardization of the lime-sulfur wash. The work in 1905 indicated the inefficiency of numerous formulas, which were consequently discarded, and indicated the value of others, which were further tested in 1906. Certain

caustic soda-sulfur washes have also been tried, as well as the principal proprietary miscible oils now on the market and concerning which there is considerable inquiry from orchardists. All of these tests have been carried out in three latitudes, namely, Georgia, Maryland, and northern Pennsylvania—on peach in Georgia, and on peach and apple in the others.

An extended chemical study of the lime-sulfur and other washes, undertaken in cooperation with the Bureau of Chemistry, has been practically finished.

PLUM CURCULIO INVESTIGATIONS.

In the work on the plum curculio, in addition to careful life history studies, special attention has been given to determining the value of applications of arsenate of lead. The value and expense of jarring on a commercial scale has also been determined for comparison with similar data as to spraying. In the Middle and Southern States the repeated applications of any arsenical to peach, as is necessary to control the curculio, is followed by more or less injury to foliage and fruit, varying in extent apparently with weather conditions. It has been necessary to secure definite information on this matter, and all of the available arsenicals were tested on peach, used with and without lime, and careful notes were made as to the extent of injury. Photographs were made showing the effects of treatment in the defoliation of trees. All of this work was carried on in triplicate at the Pennsylvania and Georgia field stations and on the Arlington Farm near Washington, D. C.

PEACH BORER INVESTIGATIONS.

Work with the peach borer was also continued as in 1905, especial attention being given to the life history studies in order to ascertain for the latitudes of the respective field stations the period of emergence of the moths as bearing on the time to make applications of washes and other forms of protection of trees. Some eight or ten different washes and protectors considered most likely to be valuable are being tested. Some time has been given to developing a sticky preparation, consisting largely of cotton-seed oil and resin, which it is hoped will protect and not injure the trees.

CODLING MOTH INVESTIGATIONS.

A special investigation of the codling moth in the Middle West was undertaken May 1, in connection with the investigation by the Bureau of Plant Industry of the apple scab. Demonstration in codling moth control was also inaugurated in several counties in southeastern Nebraska, in Missouri, and in Arkansas, in conjunction with similar work by the Bureau of Plant Industry in the control of apple scab and bitter rot. A field station was established at Nebraska City, Nebr., and here especial attention is being given to an investigation of the generations of the insect and the testing of means of reducing injury from the second generation. The demonstration work is in cooperation with orchardists, this Bureau and the Bureau of Plant Industry furnishing plans for the experiments and information concerning the application of the sprays. Labor and necessary chemicals are furnished by the orchardists.

OTHER WORK.

Several additional insects of deciduous fruit trees have been carefully studied, namely, the black peach aphid, the trumpet leaf-miner of the apple, the peach lecanium, climbing cutworms, canker-worms, and others. Attention is given to the bringing together of as many fruit insects as possible, with examples of their work. Much use is made of the camera in making photographs of insects and their work, and of orchards and subjects related to the investigation.

COOPERATION WITH EXPERIMENT STATIONS.

The entomologist of the Maryland Agricultural Experiment Station is cooperating with the Bureau in the lime-sulfur work, peach borer, and plum curculio investigations. The Georgia State entomologist is cooperating in the peach borer work and tests of arsenicals on peach foliage. On a plan submitted by the Bureau, the Georgia State entomologist has also undertaken a study of the codling moth in that State. The entomologist of the Tennessee Agricultural Experiment Station is cooperating in the peach borer work, and the Missouri Fruit Station at Mountain Grove in the codling moth work. The horticulturist of the Nebraska Experiment Station is cooperating in the codling moth demonstration work in that State.

FIELD-CROP INSECT INVESTIGATIONS.

Mr. F. M. Webster, special agent in charge of Field Crop Insect Investigations, has carried on the work outlined in the last annual report, and has taken up several new lines. The most important aspects of his investigations during the past year have been those upon the Hessian fly and those upon joint-worms.

HESSIAN FLY INVESTIGATIONS.

A further investigation of the distribution of the Hessian fly, except in the Pacific region, has failed to reveal its presence in even limited numbers south of the Arkansas River, in spite of occasional reports to the contrary due to misidentification, and it has been found that it only occasionally extends west of the one hundredth meridian, and then only for a short distance. An assistant has made a very careful survey thru the western Dakotas, Montana, Wyoming, western Kansas, Nebraska, Colorado, and Oklahoma, and the foregoing statement is the result of his investigations. On the other hand, it has been found to extend farther south in Georgia and South Carolina than has been supposed, and is troublesome in central Georgia and for some distance south of Columbia, S. C. It also affects wheat nearer the coast in North Carolina than had been supposed. The most serious outbreaks have, however, during this year, occurred on the Pacific coast, where, on account of lack of funds, the Bureau has been unable to study it.

The wheat-sowing experiments, to determine the best time to sow wheat in the fall to ward off autumn attack, have all been continued in the different localities indicated in the last report, namely, Sault Ste. Marie, Bellaire, Clare, Lansing, and Hudson, Mich.; Andover, Rockaway, and New Richmond, Ohio; Richmond, Ind., and Dublin,

Va. One station has been added in western Kentucky, one in South Carolina, and two in North Carolina, in addition to one undertaken in cooperation with the Agricultural Experiment Station at Knoxville, Tenn., and several in Georgia in cooperation with the State board of entomology. Tabulated with reference to States, these experiments are located as follows: Michigan 5, Ohio 3, Indiana 1, Kentucky 1, Tennessee 2, Georgia 3, South Carolina 1, North Carolina 2, Virginia 1. The results obtained have shown more clearly than ever that it will be possible for the wheat grower to so time his seeding in the fall as to evade this pest to a large extent and thus prevent losses. Exact data with consideration of dates will be published.

The effects of meteorological conditions during the few weeks prior to seeding in the fall as bearing upon changes of date of planting, consequent upon immediate conditions of any one given year, have also been carefully studied in collaboration with the Weather Bureau stations in the several States. While it is as yet too soon to give out definite instructions to farmers as to when and when not to sow in the fall—two years being too short a time to determine the precise effects of variations in season—yet farmers are already beginning to profit from the results of these experiments. In the case of fields sown in different localities, the assistants engaged in this investigation are able frequently to tell almost the exact date of sowing, and in some cases, by observing the extent of Hessian fly attack, to collect the data given them by the owners. Thus, while the main facts have already been secured, it will require several years' observation and collaboration in order to acquire a thoro knowledge of the effects of weather, elevation, and possibly other factors not yet developed.

Careful study has shown that the macaroni wheats are almost entirely immune from Hessian fly attack.

THE HESSIAN FLY IN THE SPRING-WHEAT REGIONS.—Investigations of this subject have been continued, and as nearly as can be told from the records of two similar years, the life history of the fly is fully established. This is of great value, since from what we know of the life history of the insect in winter-wheat regions it had seemed practically impossible for the species to exist in any number in territory planted exclusively to spring wheat. There has been, therefore, in spring-wheat infestation, a decided change in what was considered to be the normal life history of the insect. In short, the Hessian fly problem in spring-wheat regions is so different from that in winter-wheat regions that we are obliged to take it up as tho we were dealing with a new pest. While it is as yet too soon to begin to lay down rules for the guidance of the farmer, it is safe to say that at least one measure so efficient in warding off attack in fall wheat, namely, late sowing, must here be reversed, and the earlier the crop is sown in the spring the less liable it will be to fly attack. And then, too, spring wheat will send up shoots or suckers from the old roots after the straw has matured, and the pest will breed on these as freely as on the original growth when young. Winter wheats do not have this habit. Ensconced in these suckers or in volunteer wheat larvæ in protected situations will continue to live and develop even when the temperature at night occasionally falls to $+4^{\circ}$ F. This kills off most but not all of the young larvæ up to the half-grown condition. This

aftergrowth not only tends to protect from severe cold, but greatly modifies the effect of burning the stubble.

Parasites.—The investigations seem to show at the present time that the success or failure of spring-wheat culture north of central Iowa and the Platte River depends upon two very minute parasites, namely, *Polygnotus huachuca* Ashm. and *P. hiemalis* Forbes. But for these two insects the Hessian fly would render wheat growing impossible in this section. They deposit their eggs in the eggs of the Hessian fly, and the adults emerge from the pupæ or "flaxseeds," as many as 28 parasitic larvæ having been found in a single "flaxseed." Where these parasites swarmed in the fields during the summer of 1905, no adult Hessian flies have been found this season by sweeping, and so effective have they been in suppressing the Hessian fly about Tower City, N. Dak., that the field agent in charge of the work at that point, Mr. G. I. Reeves, has been obliged to go to Fessenden, where he was unable to find these parasites last year, in order to get unparasitized "flaxseeds" with which to follow out some of his more delicate experiments. These are the parasites which we tried to introduce into Kentucky and Tennessee and also into California last year. Whether they have established themselves in these localities we are not yet aware. Owing to lack of funds and assistance, the results of this parasite work can not be followed up at present. It is quite possible that had the Bureau been able to establish a field station on the Pacific slope, any number of these parasites could have been rushed to the outbreak in the State of Washington, where the wheat crop is being so badly affected that the local authorities have advised the burning of wheat in the field to destroy the fly.

It has been demonstrated in the laboratory at Washington, D. C., that these parasites can be retarded or accelerated in their emergence by controlling the heat and moisture. On a large scale this can in all probability be done by cold, dry storage and hot, humid field conditions. It has been shown that these same parasites were equally effective in the winter-wheat regions.

JOINT-WORM INVESTIGATIONS.

It has been ascertained that the timothy joint-worm reduces the seed crop from 5 to 18 per cent and injures the hay crop to a less degree. The intensity of attack seems to vary in proportion to the time the ground has been continuously planted with this grass. The insect occurs over the entire country of the United States east of the Rocky Mountains wherever timothy becomes the principle forage crop. A new and undescribed parasite is increasing rapidly over nearly this whole area.

A large series of experiments has been carried on by an assistant, Mr. W. J. Phillips, to determine whether this insect infests the uncultivated grasses and is therefore likely to spread from these to meadows, or whether there are any migrations between such grasses and the cultivated grains.

An enormous amount of material has been bred from all sections of the country, and many species of joint-worms are found. A number of them, still undescribed, are found to be engaged in grain and grass attack.

An interesting and seemingly valuable parasite of the wheat joint-

worm, belonging to the genus *Cryptopristus*, is rapidly increasing in abundance in the East and seemingly pushing its way westward. It is two-brooded, and develops one generation before and one after harvest. From wheat stubble collected in Michigan an average of a little over nineteen parasites issued to one joint-worm, and from a bunch of stubble collected at Kensington, Md., the proportion was one joint-worm to thirty-one parasites.

Important studies were made to determine the effect on the wheat joint-worm of passing the straw thru a thrashing machine. Heretofore it has been thought important that the broken hard bits of straw that contain the joint-worm should be burned to destroy the pest. The results indicate that the action of the thrashing machine is fatal to a large percentage of the insects and that the danger from the broken hardened bits of straw in fields, barnyards, and about elevators has been overestimated.

MISCELLANEOUS INVESTIGATIONS.

Studies have been made of clover-seed and clover-root insects, and two circulars of information have been issued. Studies of the corn root-louse, which is at present one of the most serious pests of the cornfield, the southern corn root-borer, the smaller corn stalk-borer, and the southern corn leaf-beetle have been made. A serious cut-worm injury to corn in western Pennsylvania and Ohio and serious ravages of a carabid beetle, *Clivina impressifrons*, in the Middle West have been studied.

WORK ON INSECTS INJURIOUS TO VEGETABLE CROPS.

Investigations on the insect enemies of vegetables and other truck crops have been continued by Mr. F. H. Chittenden along the same lines as conducted in previous years. Lack of funds has rendered the practical results less valuable than should be the case. The expert in charge of this line of investigation has been practically without assistance during the fiscal year.

The subject of insects injurious to sugar-beet culture in the West, which was taken up as a special topic for investigation in recent years, has been continued. A very destructive leaf-hopper (*Eutettix stricta*), known locally as the white fly and the blight, the latter name being due to the effects of its operations on sugar beet, was the cause of serious damage and much complaint in Utah, Idaho, and Colorado. A special agent was employed in cooperation with the Utah State Experiment Station to study the conditions and to devise means for its suppression in the infested district. A considerable proportion of the species of sugar-beet insects observed and collected in 1904 have been worked up, but the work on the life history of the remainder will still require some time to complete.

The continued spread of the asparagus beetles westward and northward has rendered it necessary to revise a popular article on these insects, published in the Yearbook for 1906, for use as a Farmers' Bulletin.

Additional observations have been made in regard to the pepper weevil, a new pest in this country, related to the cotton boll weevil and occupying a similar region. These results are available for publication.

Root maggots, which have been unusually destructive since about 1903, have been under continuous observation, and some species which have never before been fully investigated have been the subject of special study. One form in particular has done great damage in Alaska, and thru the kindness of correspondents and the cooperation of Dr. C. C. Georgeson, special agent in charge of the agricultural experiment station at Sitka, some facts not previously recorded in regard to this insect have been gained. Owing to the coldness of the climate in Alaska the insect makes its appearance considerably later in the season than in the principal infested districts of the Eastern and Middle Western States.

The common stalk borer (*Papaipema nitela*) has been under especial observation during the year owing to its recent severe depredations. The egg-laying habit and the hibernation of the insect in the egg stage, as well as other data which have been accumulated, are all of value in indicating methods of control. Practical exemplification of the utility of these methods has been had. A comprehensive account of this and related forms is in course of preparation.

The melon aphid has been the subject of practical experiments, especially in Texas, in cooperation with the Texas Agricultural Experiment Station. A method of controlling this insect on its first appearance in the fields of melon, cucumber, and other cucurbits has been devised and is now being perfected. It consists in fumigating the plants with nicotine preparations, which give instant and, if continued, permanent relief against the ravages of this serious pest. A comprehensive, general, and economic account of this species, with directions for its control by this and other methods, is nearly complete and will soon be published. A frame method of fumigation by means of nicotine preparations will be found applicable to other forms of plant lice affecting vegetable crops, as, for example, the cabbage aphid, which is a pest locally in certain years.

Other species studied are certain forms of cutworms, the tobacco flea-beetle, and the larva of the striped turnip or cabbage flea-beetle, responsible for a new form of injury to radishes.

INVESTIGATIONS OF INSECTS IN THEIR DIRECT RELATION TO THE HEALTH OF MAN AND DOMESTIC ANIMALS.

The work of the year in this direction has comprized investigations of three kinds, namely, work on mosquitoes, work on the house fly, and work on the Texas cattle tick.

MOSQUITOES.

* During the first few months of the fiscal year under consideration the outbreak of yellow fever in certain of the Southern States once more drew attention to the yellow-fever mosquito, and, as indicated in the last report, the work previously done by the Chief of the Bureau in regard to the geographic distribution of this dangerous insect was extensively used by the Public Health and Marine Hospital Service in basing its recommendations in regard to quarantine measures. On the return of the Chief of the Bureau in August from Europe, where he had been engaged arranging for the importation of the parasites of the gipsy moth, he took up a further study of the

yellow-fever mosquito, and in the autumn visited New Orleans and portions of Texas in pursuance of this work. Some new and important points relating to the habits of the species were ascertained, and some valuable experiments were made with remedies and methods of destruction, both in the larval and adult conditions.

Further work on mosquitoes has been carried on thruout the year in cooperation with the Carnegie Institution of Washington, and very complete records have been brought together of the life histories and geographic distribution of nearly all of the mosquitoes inhabiting North and Central America and the West Indies. The information thus gained is being brought together in monographic form, and when published it is hoped that it will be of value to the medical profession and form a sound basis for the identification of species, the determination of their disease-bearing possibilities, and for general information to all interested.

THE HOUSE FLY.

In the spring of 1906 a publication was issued on the subject of the house fly, calling attention to its agency in the spread of typhoid fever, pointing out the proper methods for its control, and urging the adoption of these methods by individuals and communities. The unusual spread of typhoid in the city of Washington during the summer, following as it did the complete installation of the elaborate water-supply filtration plants—an occurrence unique in the history of sanitation—drew marked attention upon the house fly once more as one of the causes, altho not the principal one, of the transfer of this disease. Based partly upon the investigations of the Bureau, the health authorities of the city issued in May an order respecting the proper care of stables (where house flies breed), but were unable, thru lack of a sufficient inspecting force, to carry the regulations into effect. Observations were made by the Bureau, partly in cooperation with the health officer, upon a series of stables in two different regions of the city, and it was shown on a somewhat large scale that it is a comparatively easy matter greatly to reduce the numbers of the house fly in any given community at a comparatively slight expenditure of funds and effort. These facts will be displayed in a revised edition of Circular No. 71 of the Bureau.

WORK ON THE TEXAS CATTLE TICK.

As indicated in the last report, the Bureau of Entomology has for some time been urged by southern entomologists and cattle raisers to undertake work on the cattle tick. This was begun at the close of the fiscal year 1905 and continued thruout the fiscal year 1906 in connection with the investigation of the cotton boll weevil. Prof. H. A. Morgan, director of the Tennessee Experiment Station, who has done more work on the biology of the cattle tick than anyone else in this country, furnished the Bureau with a very large amount of his unpublished notes and also his suggestions and advice as to the lines which could be followed with the best promise of practical results. The work done by the Bureau has been planned in such a way as to furnish the information about the tick which is absolutely necessary in the so-called pasture or field-lot system of eradication. In order

to follow these methods intelligently, it is necessary to have information concerning the length of development of the different stages under different conditions of host, climate, and season. It is also necessary to ascertain by what means dissemination of the ticks takes place—that is to say, whether floods, winds, or animals other than live stock may be responsible for introducing ticks into new regions. The cooperation of the entomologists in the States of Louisiana, Arkansas, Alabama, Tennessee, and South Carolina was gained. Thruout the season material was sent to them from the laboratory at Dallas, Tex., and outlines were also prepared there in order to bring about uniformity in the work. At Dallas a steer was obtained, and during the season six full generations of the tick were raised upon it.

This work has already considerably increased our knowledge of the development of the tick. In addition to this work, it was found possible, incidentally, to investigate the life history and habits of a number of other common ticks which are likely to be confused with the fever-transmitting species. Some of these other ticks are rather serious pests, and in some cases may be found to transmit diseases. This work, however, has been made strictly secondary to the work on the true Texas cattle tick (*Boophilus annulatus*).

In February, 1906, an agent was placed in the field to canvass the situation in the Gulf States. The work assigned to him has been to obtain data as to the damage done by ticks and to inform farmers as to the proper local methods of eradication. He succeeded in inducing a number of farmers to start systematic plans for freeing their property of ticks. At the same time he obtained information regarding tick-free areas within the quarantine area. Such areas should be utilized in freeing the cattle of surrounding regions from ticks. It is consequently of the greatest importance to find where these tick-free areas are located and their exact extent. One such area of considerable size in Texas, the presence of which had hitherto been unsuspected, has been found.

WORK ON SCALE INSECTS.

No especially notable outbreak of scale-insect damage has characterized the last fiscal year. Nevertheless the common scale enemies of orchards and ornamentals have been continually in evidence, and a great deal of infested material has come to the Bureau for examination and determination. This applies particularly to such standard scale pests as the oyster-shell scale of the apple and pear and other plants and the scurfy scale affecting the same range of plants. The oyster-shell scale or "bark-louse" has been particularly frequently reported the present year as affecting ornamentals, practically all deciduous plants being subject to attack by it. Injury from this species has been very notable this year in western New York, and also in Massachusetts, on ornamentals and shade trees and to a less extent perhaps on fruit trees. The cottony scale of the maple (*Pulvinaria innumerabilis*) is also reappearing, but will probably be less abundant this year than last, and the belief that it will eventually be brought in subjection by its native ladybird enemy (*Hyperaspis signata*) is apparently well founded. This little ladybird developed in enormous numbers last year and should be there-

fore so abundant this year as to give a very good account of itself in the reduction or perhaps almost complete extermination, for the time being, of its host insect. The San Jose scale continues to be the most important scale pest in this country and has been the subject of careful investigations with remedies and from the standpoint of natural enemies. Bulletin 3 of this Bureau, published more than ten years ago, has been thoroly revised for reissue to bring the subject down to date. It will be published as Bulletin 62.

In Florida the white fly continues to be a very serious pest of citrus cultures, and a special appropriation has been asked for and granted by Congress of \$5,000 for a thoro investigation of this pest.

A good deal of time is devoted during the year to thoro inspection of all the new plants which the Department of Agriculture is importing from different parts of the world to detect and destroy any new insect enemies which might be brought in with them. The insect enemies likely to be brought in such plants are principally of the scale-insect family, and the careful examination which is given to such material has resulted in the destruction or thoro fumigation of a good deal of material which would otherwise have been the means of introducing important new enemies.

The laboratory investigations, particularly the determination of material for experiment stations and individuals thruout the country, is a constant feature of the work, and takes much of the time of two expert assistants. This work is under the direction of Mr. C. L. Marlatt.

WORK ON INSECTS INJURIOUS TO STORED PRODUCTS.

There has been constant correspondence in regard to insects of this class, and a constant distribution of circulars of information describing the most prominent forms. The Mediterranean flour moth continues its spread thruout the northern United States, where it now appears to be generally distributed in all of the principal milling districts from the Atlantic to the Pacific. Altho this species has been given very considerable study in this office by Dr. F. H. Chittenden, who is in charge of this branch of the work, and in some of the States where it is most injurious, there is still much to be learned in regard to the effect of certain fumigation methods in its control. This, and other species injurious to stored products, can be destroyed by the use of hydrocyanic-acid gas, which has some advantages over bisulfid of carbon, one of which is that it can be used where the latter can not, on account of objections made by insurance companies issuing policies on the premises invaded. Circulars have been distributed describing the use of hydrocyanic-acid gas. This substance has the objection of danger to human life, except where the utmost care is taken, and investigations are being made with other substances not inimical to human beings.

EXPERIMENTAL WORK WITH INSECTICIDES.

A certain portion of the work of this class has already been mentioned under the head of "Investigations of Insects Damaging Deciduous Fruit Trees," altho the general subject is placed under the management of Mr. C. L. Marlatt, the assistant chief of the

Bureau. Aside from this the particularly new work during the fiscal year 1906, alluded to as begun in the last report, has been careful experimentation with sulfurous acid gas (SO_2 and SO_3), for the disinfection of granaries or other storages of grains or seeds, or for the disinfection of dwellings and similar uses. These tests were carried out on a very liberal scale and in a very thoro manner, and fully demonstrated the field of usefulness for this gas. A report on this experimental work is now in process of publication.

The routine work has been carried on during the year, covering species tests with standard insecticides, the fumigation of mills, granaries, and dwellings against insect pests, and the examination and report on the many new insecticide ideas or decoctions which come to the Bureau for attention almost daily. Nine-tenths of these supposed means of insect control are either useless or a reproduction of methods, with or without modifications, which are already well known. Nevertheless the examination of these substances and the correspondence relating thereto takes up a good deal of time.

In the case of the treatment of orchards with insecticides for various insect pests, a great deal of experimental work has been done with the lime, sulfur, and salt wash, twenty different formulas being tested in three localities in as many States. Similar tests have been made in the same localities with the so-called miscible oils. These tests all relate to the control of the San Jose scale.

WORK IN BEE CULTURE.

There has been a decided increase in the work in this branch during the past fiscal year, due in no small part to the increased interest in the investigations on the part of honey producers of the United States.

A large number of queen bees of different varieties were reared and distributed from the apiary at Washington, D. C., as well as from the substation at Chico, Cal. The plan for this distribution has been modified so that it is no longer promiscuous, but the queens are placed with men who are in position to propagate desirable stock and distribute it widely among the bee keepers of the country. The Caucasian race received the most attention. A stock of this race is now offered for sale by reliable dealers, most of whom have received their stock thru the Bureau. Cyprian and Carniolan queens have also been sent out.

Investigations of the giant bees of India and the Philippines were continued during the year, and Mr. Frank Benton, in charge of the work, has from time to time since reaching India sent in reports of these bees. The results of this work should be known to the Department within a few months.

The various methods of queen rearing were tested in rearing queens for distribution, and a bulletin entitled *The Rearing of Queen Bees* was written by Mr. E. F. Phillips and has been quite widely distributed upon application from persons interested. It deals with the modern methods of queen rearing and brings together our knowledge upon the subject.

During the year Mr. Phillips, in charge during Mr. Benton's absence, attended various bee keepers' conventions and delivered

addresses in cooperation with the New York State Department of Agriculture and the Pennsylvania State Bee Keepers' Association.

The substation at Chico, Cal., with Mr. J. M. Rankin in charge, was continued, with results which are all that can be expected with the present limited facilities for the work. The principal work was on the honey-producing plants, and this was done in cooperation with the Bureau of Plant Industry. The results obtained are in no small part due to the great kindness of Mr. P. H. Dorsett, of the Bureau of Plant Industry, who is in charge of the plant-introduction garden at Chico, Cal. A considerable number of plants have been propagated which are remarkable honey producers. During the previous fiscal year the seeds of certain honey-producing plants were distributed to a number of bee keepers thruout the United States. The reports received during the last year, however, showed that with few exceptions they were of little value.

BEE DISEASES.

The work on brood diseases of bees occupied a considerable proportion of the time of the force. The bacteriological work connected with the investigation was done by the bacteriologist assigned to this subject in the Bureau of Animal Industry. As a result of this investigation, the confusion which has existed in regard to brood diseases has been to a certain extent cleared up, and the work of fighting these diseases will be benefited by the added information.

A trip of investigation of bee diseases, particularly the one commonly known as black brood, was made thru New York State in the spring of 1906, and proved to be very valuable. The trip was made in cooperation with the four New York State inspectors of apiaries.

In the late summer of 1905 the California agent made a preliminary investigation of the disease known to bee keepers as paralysis, in the San Joaquin Valley, California. A large number of samples of diseased brood from various diseases have been diagnosed.

ROUTINE WORK.

The correspondence in bee culture has practically doubled within the year. Card catalogs have been prepared of queen breeders, dealers in apicultural supplies, and bee-disease inspectors; the mailing list has been completely revised, and an index of American bee literature has been made.

WORK IN SILK CULTURE.

The silk-culture work of the Bureau has been continued in almost exactly the same manner as during the previous fiscal year. Mr. C. J. Gilliss has had immediate charge under the Chief of the Bureau. The correspondence has increased to a certain extent, and nearly 3,000 letters were received. The interest exhibited by correspondents seems, as in the fiscal year 1905, to have been most marked in the State of New York, but during the fiscal year 1906 California has shown a greatly increased interest. The other principal centers of interest seem to have been Illinois, Massachusetts, Michigan, New Jersey, Ohio, and Pennsylvania. There was decreased correspond-

ence in most of the Southern States. This does not mean, however, that there has been an actual decrease in the number of persons raising silk in this region, since in some cases we know that the raiser has produced his own eggs and has begun work in producing cocoons without recourse to the Bureau. It is interesting to note that the direction of increase in interest follows the line of publication of syndicate articles on the subject of silk culture in the newspapers. The course of certain of these articles has been traced, and it has been shown that this year they traveled in a line from the New England States to California, following the northern boundary of the country, while little or nothing has been published in the Southern States.

PURCHASE OF SILKWORM EGGS AND THEIR DISTRIBUTION.

As in previous years, the egg supply has been bought in Europe, from well-known houses, where the latest methods for the detection of disease are practised, and from which eggs are sent out only under guaranty of health. Eighty ounces were imported from Italy in this way. In addition to these some 20,000 eggs of a new race were donated to the Bureau by an Italian firm and some 40,000 were sent in by Consul Young from Harput, Turkey, with the information that they were of a race commonly used for importation into Russia and Prussia. The Italian eggs were sent to Barnegat, N. J., and the Turkish eggs to Florida. The latter having arrived in February and having been found to be nearly all hatched, it was necessary to send them to a southern point, since no leaves could be obtained in the North.

HOME PRODUCTION OF EGGS.—Altho the Bureau has never encouraged the home production of eggs, and, in fact, has urged that they should not be produced at home, showing the discouraging effect on the industry, it seems almost impossible to prevent it. In fact, fully one-third of the individuals sending in cocoons have not received eggs from the Department. Of course one way to effectually discourage this practise would be not to buy cocoons from such persons, but the Bureau hesitates to take this extreme course until positive proof of the existence of disease among home-raised eggs is gained.

HEALTH OF EGGS.—Careful watch has been kept for traces of pebrine, but no new cases have been noted. It still continues to exist at an establishment in Cuba. The person in charge was directed to take precautionary measures, fumigating rearing rooms and materials, and later, as the disease grew worse, he was advised to discontinue raising silkworms for one year. He has been requested to send no samples of cocoons or anything connected with silk raising to this country. At one place in California where it existed last year it is thought now that it has been stamped out.

Careful experiments have been made as to the effects of cold storage on eggs, and it has been noted that for eight months there are apparently no ill effects and no weakening of vitality. It was confidently expected that they might therefore be safely left for at least twelve months, but during the ninth month a change took place; the eggs began to lose their plump appearance and the ends to sink in. At twelve months not more than one egg out of several hundred could be induced to hatch and at fourteen months none at all.

DISTRIBUTION OF EGGS.—In the winter and spring eggs were sent to 413 individuals in 47 different States and Territories, as against 356 individuals in 42 States and Territories during the previous fiscal year, showing a slight increase in interest.

DISTRIBUTION OF MULBERRY STOCK.

As in the previous year, seedlings of the best white mulberry were distributed to all applicants during the late fall and spring, none being sent out during freezing weather. Last season (1905) 48,560 seedlings were distributed and this season (1906) 34,575. The seedlings of this season, however, reached a much larger number of correspondents, since the trees were sent out in smaller lots. Excellent results are reported from all quarters regarding the growth of the trees, which would seem to indicate that they are of the finest quality. The States receiving the most were California, Illinois, Virginia, Michigan, Wisconsin, New York, and Connecticut.

Four kilograms of mulberry seed have been purchased in Lombardy for next season's supply of seedlings—1 kilogram of a Sicilian variety and 3 kilograms of a Lombardian variety.

The mulberry orchard at the Arlington Farm has been carefully attended during the year, and the new orchard planted to several acres last year has been enlarged by $1\frac{1}{2}$ acres.

COCOONS PURCHASED.

Between July 1 and October 4, 1905, American-raised cocoons were purchased, whenever offered for sale, at the rate of from 75 cents to \$1 per dried pound, the producer being required to pay transportation charges. On October 4 the rate was raised 15 cents per pound on all classes. In addition the Government assumed the expense of transportation, providing freights to be sent to producers on application. The end of the fiscal year, however, found a falling off in the number of pounds of cocoons offered for sale as compared with the record for the previous year. An encouraging fact, however, as opposed to this is that the quality of the cocoons has greatly improved, and it is hoped with some grounds that the quantity of the cocoons offered will be considerably increased the coming year.

REELING OPERATIONS.

Reeling has been carried on in the same manner as formerly, with the one 4-basin Berthoud machine in use, there being no available space for setting up the second machine. At the end of the fiscal year 1905 reeling was being carried on with four operators at the basins and one at the beating device. At the end of November the reel was shut down, owing to lack of cocoons, and was resumed in February, 1906. It was shut down again in April and started again about the middle of June. Four, five, or six threads have been used, according to the skill of the operator and the nature of the cocoons employed.

Under the present system the greatest amount of cocoons which can be reeled in a day by one operator is $1\frac{1}{2}$ pounds. This might be increased to 2 pounds daily if all the cocoons were of a good quality.

The amount of reeled silk turned out is about 1 pound for each $3\frac{1}{2}$ or 4 pounds of cocoons, sometimes dropping lower if especially poor cocoons are used.

Samples of the silk reeled were submitted for expert examination, and were discovered to be inferior to the best, owing to lack of skill on the part of the operators. The samples submitted were graded as Ardeche Classical silk, which ranks as the second grade of Cevennes silk.

MISCELLANEOUS INVESTIGATIONS AND OTHER WORK.

Several investigations of importance have been carried on which will not fall under any one of the headings so far used, and of these the principal ones may be summarized here.

Work on insects injurious to strawberry, and raspberry, blackberry, and other bush fruits has been continued, and a difficulty which has presented itself from time to time, namely, the identification of certain injurious forms whose names were generally confused, has been satisfactorily settled, and articles on some of these species will shortly appear. Prominent among these are several forms of leaf-rollers, root-worms, and related forms. One of these pests, known as the strawberry crown-girdler, has become a great pest during the year in portions of the State of Washington, and investigations have been begun looking toward better methods of control than are known at present.

A very considerable number of insects injurious to flower gardens and in greenhouses have been studied, both in the city of Washington and by cooperation of correspondents. A special study of the insect enemies of roses has been under way, and it is hoped will soon be completed.

The corn root-aphis in its occurrence upon dahlia, aster, and related composite plants has been studied.

Many complaints are received each year of insect injury to shade and ornamental trees. The chief tree defoliators have been treated in publications now available, and some of the borers have been considered, but considerable progress has been made in methods of treating these pests, particularly the latter class, and work which has been carried on for some time on the principal insect enemies of shade trees will be pushed rapidly forward to the end of a publication of a comprehensive account of these pests. Among the shade-tree insects which have greatly extended their range of injuriousness and which require special treatment are the imported willow or poplar curculio, the willow leaf-beetles, the bronze birch borer, and the greenhouse red spider, which latter has become a pest of some seriousness on shade trees. This leaves out of account the gipsy moth and brown-tail moth, which are the subject of investigations to be paid for from funds provided by Congress for the fiscal year 1907.

An investigation of the habits of the gadflies of the family Tabanidæ has been completed, and a special report is about to be issued.

The correspondence of the Bureau has increased, necessitating an enlargement of the clerical force. More than 30,000 letters were written during the year, and many queries were answered by the aid of circulars.

The routine work in the insectary has increased also, and biological studies have been made of nearly 500 species not hitherto studied, and the biological numbers now reach 11,688, each number

meaning that a distinct species has been studied from time to time in the insectary and notes made upon its life history.

The work of determining specimens for the entomologists of the State experiment stations and other workers has also increased. Many thousands of insects have been received from these workers, and a certain proportion of the time of a number of expert assistants was taken up in this way.

PROPOSED WORK FOR THE FISCAL YEAR 1907.

The work for the fiscal year 1907 is, at the date of this writing, already well under way, and will consist for the most part in following out the lines of investigation just indicated.

Two new lines of work, however, of great importance have been added during the present fiscal year. The first of these, an investigation of the white fly of Florida and the Gulf regions, has been started by the assignment of a trained entomologist, Mr. A. W. Morrill, in charge, under the direct supervision of Mr. C. L. Marlatt, Assistant Chief of the Bureau, who has general charge of insects affecting tropical and subtropical fruits. The white fly is an insect which has done very considerable damage to the orange and lemon groves of Florida and which has been spreading and increasing. The agent in charge has made a preliminary investigation and has established headquarters at Orlando. Every possible phase of the life history of the white fly will be investigated, and careful work will be done on the remedial side.

The second new investigation of importance is that of an effort to prevent the further spread of the gipsy moth and the brown-tail moth in New England. There is a radical difference in the possibilities of effective work for the prevention of the spread of these two insects. The brown-tail moth flies readily in both sexes and has already covered a very great extent of territory, ranging from Amherst, Mass., to a point high up the Maine coast. At the time of its annual flight it is carried by the prevailing winds possibly for hundreds of miles, and an effort to prevent its spread seems hopeless except by the active cooperation of every property holder within the infested territory. The means by which it may be destroyed, however, are simple. Its winter nests are conspicuous objects on the terminal twigs of trees and shrubs in the winter time after the leaves have fallen, and it is a simple matter to cut them off and burn them, every one destroyed meaning the death of 250 caterpillars on the average. The campaign against this insect, therefore, must be in the first place an educational one, and in the second place one of local effort to enforce its destruction. The principal measures are therefore local or State police measures. The Bureau will do all that it can to assist in the educational part of the movement and will endeavor to assist State authorities and communities to carry out the work of destruction.

With the gipsy moth, however, the case is different. The female can not fly, and the species is distributed by means of the caterpillars, which, spinning down from trees overhanging roadsides, are carried long distances by automobiles, carriages, trolley cars, and other vehicles; and shorter distances by pedestrians. The plain method of preventing its further spread, therefore, is to exterminate the

insect upon roadside trees in the thickly infested centers. The main center of infestation is at the present time eastern Massachusetts, the territory from Worcester to the coast being well covered. The range extends continuously north into New Hampshire and probably beyond into southwestern Maine.

There are two isolated colonies, the one in the city of Providence and the other at Stonington, Conn. By cooperation with the State authorities the Bureau will endeavor to stamp out the isolated colonies in these two States. Further than that, it will during the coming autumn and winter endeavor accurately to determine the exact localities in which the insect exists in the States of New Hampshire and Maine. But the main work in preventing the further spread will be done in the State of Massachusetts, by cleaning up the main thoroughfares leading out from the regions of thickest infestation.

Headquarters have been established at Boston, a trained man, Mr. D. M. Rogers, has been put in charge of the work, and gangs of men are already engaged in the roadside cleaning. This work will be continued thruout the fiscal year.

The importance of the continuation of the experimental work on the boll weevil has been pointed out elsewhere. The pest is invading new regions, where the local conditions must give the problem of its control aspects entirely different from those represented elsewhere. In Texas the cultural method of controlling the pest has been found to be effective. This is to a large extent due to the comparatively small rainfall. In the localities where the rainfall has been greatest damage has always been most severe. In the Red River Valley in Louisiana and the Mississippi Valley the general conditions are exactly like those which have caused the greatest difficulty in controlling the insect in Texas. In some localities in the latter State it has been necessary to substitute other crops for cotton. In Louisiana, where similar conditions prevail, on account of industrial conditions it will be impossible for the planters to dispense with the cotton crops. Accordingly, the problem of weevil control in the regions into which it is just entering is by no means solved. The annual precipitation averages 20 to 25 per cent greater than in Texas. Moreover, the more or less general situation of the cotton fields near timber, affording abundant opportunities for successful hibernation, also adds to the difficulties of the problem.

At various times the suggestion has been made that instead of early planting, as advocated by the Bureau and successfully practised by a large number of planters, late planting might under some conditions be more feasible. This idea has been based upon the heavy mortality of hibernating weevils. It has been supposed that by the fall destruction of the plant and the preventing of the maturity of late broods by late planting, the period of hibernation would be so prolonged that no weevils would survive. Altho a large amount of experimental evidence already in possession of the Bureau tends to show the fallacy of this theory, it has been planned the present year to greatly augment our information. In order to accomplish this, after considerable search six isolated fields have been selected at points in Texas and Louisiana which will give a great variety of climatic conditions. On the fields which were finally

selected the planting of the crops was deferred until about the 10th of June. At the end of the season the Bureau will have complete information regarding the possibility of evading the weevil by late planting. As a matter of fact, it has already been found that late planting is a failure in one instance, since considerable infestation has been found in a field planted on the 10th of June in Llano County, Tex. It is to be noted that the hibernation experiments mentioned elsewhere also have an immediate bearing upon the theory of late planting. In the cages at Keatchie the weevils which were placed there November 18 were found not to have emerged until the 27th or 28th of June.

The need of more extended experiments than have hitherto been possible in the practical effect of fall destruction of cotton stalks in fields has been evident for some time. A great deal has been done by the Bureau in this direction, but the practise has not been taken up by the planters to the proper extent. During 1906 it is planned to carry on large-scale fall destruction experiments which will serve as a practical demonstration to the farmers in at least two localities. Two rather favorable locations have been found—one in Calhoun County, Tex., and the other in Cameron Parish, La. In each case about 400 acres of cotton have been found completely isolated. The early destruction of the stalks will be begun in September, 1906.

The Bureau will pay very especial attention to the possibility of controlling the weevil in the eastern portion of the cotton belt. Much of the work being done in the laboratory will throw light on this problem.

Especial attention is being given to the adaptation of the weevil to climate and food conditions and protection, as well as the relation between climate, enemies, and food supplies in the multiplication of and injury by the pest.

During the present year experimental work will also be conducted, especially in regions where the greatest damage is certainly to be expected. This has been arranged by reducing the number of experimental farms in Texas and the curtailing of the acreage in others.

In regard to the importation of parasites the work on the introduction of the European parasites of the gipsy moth and the brown-tail moth will be continued thruout the year. Additional sendings from all parts of Europe of the brown-tail moth nests will take place during the autumn and winter, and with the opening of the season of 1907 both species in all stages will be sent over by paid and volunteer agents.

Other beneficial European insects, including parasites, will be imported, and the Assistant Chief of the Bureau, Mr. C. L. Marlatt, is at the time of this writing in Europe engaged upon this mission.

Experimental work upon the kelep, or Guatemalan ant, will be practically discontinued, since, as shown elsewhere, little is to be expected from this ant in the southern United States.

In the work on forest insects the investigations outlined in the previous part of this report will be continued with a reserve fund held for the investigation of any new outbreaks of insects of this class.

In regard to deciduous-fruit insects, it is planned to continue the investigations of the plum curculio, peach borer, and miscellaneous

peach insects. The test of the lime-sulfur wash, in progress for two years, it is hoped may be concluded, at least in its present scope, by the fall of 1906.

The experimental and demonstration work with the codling moth in the Middle West is to be continued, but headquarters may be changed from southeastern Nebraska to southern Missouri, where the fruit interests are more extensive.

In the field-crop insect work the wheat-sowing experiments are all to be continued except at the station in extreme northern Michigan, which will be abandoned. The eastern coast series will be extended northward to Canada in cooperation with the Pennsylvania and New York experiment stations. The North Dakota station will be changed to Manhattan, Kans. A special investigation will be made in the matter of invasion of reclaimed areas in the West by corn and forage-crop insects, following the work of the Reclamation Service. It is hoped also to take up the study of alfalfa insects and western corn insects. A substation will be established near Annapolis Junction, Md., where some of the breeding will be carried out and important field investigations undertaken.

The work on mosquitoes and house flies will be continued in a small way, but further investigations into the cattle tick must be dropt owing to the lack of appropriations for the purpose.

In bee culture especial attention to the subject of bee diseases will be given, and it is planned to have a meeting of the official inspectors of apiaries of various counties and States for the purpose of discussing the various methods of treatment under different climatic conditions, as well as the form of law which best enables the bee keepers of a given State to carry on the work of the extermination of diseases. Should the importation of the giant bees of India and the Philippines be successfully completed during the present fiscal year, steps will be taken for the propagation of these bees and eventually for their distribution. The distribution of queen bees by the Bureau will be discontinued, except in so far as it is possible from time to time to assist queen breeders in the improvement of their stock. The work of procuring and testing valuable honey-producing plants will be continued at the California substation, and an investigation of the comparative value of different races of bees in fertilizing the red clover will be undertaken in cooperation with the expert in charge of cereal and forage-plant insect investigations.

The other investigations under way will be carried on and new ones begun in case of unexpected insect outbreak.

SUGGESTIONS AS TO WORK RECOMMENDED FOR THE FISCAL YEAR ENDING JUNE 30, 1908, FOR USE IN PREPARING ESTIMATES.

It is hoped that the work upon the cotton boll weevil may be continued with funds for its support equal to the amount appropriated for the fiscal year 1907, namely, \$85,000. It has been the experience of the Bureau in the investigation of this insect that at least two years must elapse after new territory is invaded before injury by the weevil reaches its height. Therefore it will not be possible to ascertain at all completely the effect that the radically changed conditions in Louisiana and Mississippi will produce upon the habits of the

weevil until the fiscal year 1908. During that year practically all of the work in Texas will probably have been completed, and further investigations in that State may be practically abandoned, the center of investigation being moved to the neighborhood of the Mississippi River.

With regard to the effort to prevent the further spread of the gipsy moth and the brown-tail moth, the sum appropriated by Congress for the fiscal year 1907 is only \$85,000, whereas \$150,000 was asked by the New England members of Congress supporting the movement. Even with the large sums expended by the State of Massachusetts, to which must be added the appropriations already made or to be made by the States of Connecticut, Rhode Island, New Hampshire, and Maine, and possibly also Vermont, the sum of \$85,000 is too small to effectively cover operations along the main-traveled roads leading out of the most thickly infested district, which, as has been elsewhere shown, is undoubtedly the most effective way of preventing the further spread of the moth. The large sums appropriated by the State of Massachusetts are, by an arrangement existing between the State authorities and the Bureau, to be devoted mainly to the clearing up of territory away from these roads, such as the woodland tracts, in accordance with the State law which provides for the compensation by the State to towns of a certain percentage of the amount expended under the direction of the State superintendent. Should, therefore, the appropriation of \$85,000 for the fiscal year 1907 be increased to \$150,000 for the fiscal year 1908, it is certain that more effective work can be done and the spread of the gipsy moth much more effectively checked. It is recommended, for reasons which appear earlier in this report, that the brown-tail moth be not included in this appropriation clause.

An enlargement of the work now being done in nearly all of the branches of investigation under way is most desirable, and will bring results of greatly added value.

In the work on insects injurious to field crops, the amount which the Bureau has been able to expend is very small compared with the enormous value of these crops. The desirability of a field station on the Pacific coast is obvious, in view of the great damage to grains done by insects in that region during the past summer. It is also desired to undertake careful investigation of insects injurious to the apple, to extend further the investigations regarding forest insects, to undertake some elaborate selective breeding experiments with bees, and to have more funds for the investigation of bee diseases. The investigation of the white fly will need more funds before it can be carried to a proper conclusion. The services of several experts are needed in this investigation, and large-scale experimental and demonstration remedial work should be supported. The investigation into the natural history of the Texas cattle tick, interrupted at the beginning of the fiscal year 1907, as explained in the body of this report, should be resumed during the fiscal year 1908, as upon the results obtained by this investigation must depend in a certain degree the efficacy of the work of the Bureau of Animal Industry, supported by a special appropriation from Congress for the fiscal year 1907. Work on insects affecting vegetable crops should be extended, as well as upon the insects affecting the health of man.

An immediate investigation of much importance should be under-

taken during that year, and will require a considerable expenditure of money—that is to say, an investigation of the hydrocyanic acid gas treatment of trees. This method is successful against scale insects damaging the citrus fruit industry of California, and is extensively used in that State and may well be adapted to use in Florida. This fumigation is, however, more or less in an experimental stage at the present time; no thoro scientific investigation of the subject has yet been made, and the importance of the interest involved fully warrants it, the value of oranges alone shipped from southern California during the winter and spring of 1906 amounting to over \$30,000,000. Some of the points to be investigated are the life of the gas as to its effects upon scale insects at different periods, indicating the necessary time of exposure; the relative pressure of gas in light and heavy dosage, and the pressure where different proportions of water are used with a given amount of cyanide and acid; the different proportions as indicating the margin between efficiency against the insect and danger to the tree and fruit; the influence of external conditions, such as the hours of treatment, weather, temperature, moisture of the air and foliage, physical health of the tree, and many other points of similar character. This investigation has been urged upon the Bureau recently by county horticultural commissioners and representative bodies of horticulturists thruout southern California.

It is recommended, therefore, that, in addition to the emergency appropriation for the cotton boll weevil and the gipsy moth already recommended by amount, the sum of \$120,000 be appropriated for entomological investigations, an increase of \$45,000 over the sum appropriated for the fiscal year 1907. This increase is recommended, as indicated, for the normal increase of work already undertaken, and for the inauguration of new work, as also indicated.

In regard to salaries, I respectfully urge that one additional clerk of class 1 and one additional clerk of class 2 be allowed for, and that the salary of the chief clerk of the Bureau be raised from \$1,800 to \$2,000 per annum, the additional clerks being needed by the increase in the work and to allow deserved promotions, the increase in the salary of the chief clerk to be given for reasons indicated in the last report. I also respectfully urge that the Chief of the Bureau should receive \$3,500 per annum, so as to place him on a par with the chiefs of the Bureaus of Soils and Statistics, and the Forest Service, and with the Director of the Office of Experiment Stations. It will be noticed that during the fiscal year 1907 the Bureau of Entomology controls the expenditure of more money in its work than any of the other branches of the Department with the exception of the Weather Bureau, the Forest Service, and the Bureaus of Animal Industry and Plant Industry; but the salary of the chief is lower than that of any other bureau chief with one exception. This will make an addition to the salaries of \$3,050, a smaller increase by nearly \$2,000 than was asked for last year.

U. S. DEPARTMENT OF AGRICULTURE.

REPORT
OF
THE ENTOMOLOGIST
FOR
1907.

BY
L. O. HOWARD.

[FROM ANNUAL REPORTS, DEPARTMENT OF AGRICULTURE.]



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REPORT OF THE ENTOMOLOGIST.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., August 9, 1907.

SIR: I submit herewith an executive report covering the work of the Bureau of Entomology for the fiscal year ending June 30, 1907, dividing it, in accordance with your instructions, into the following headings:

(1) A summary of the important operations carried on during the fiscal year 1907.

(2) An outline of the plans proposed for work for the fiscal year 1908 under appropriations already made for that year.

(3) Suggestions as to work recommended for the fiscal year ending June 30, 1909, for use in preparing estimates.

Respectfully,

L. O. HOWARD,
Entomologist and Chief of Bureau.

Hon. JAMES WILSON, *Secretary.*

WORK OF THE YEAR.

The work of the Bureau during the year beginning July 1, 1906, and ending June 30, 1907, may be classified as follows:

(1) Work on the Mexican cotton boll weevil and other insects affecting cotton.

(2) Work on the gipsy moth and brown-tail moth.

(3) Importations of useful insects.

(4) Exportations of useful insects.

(5) Investigations of insects damaging forests.

(6) Investigations of insects damaging deciduous fruit trees.

(7) Field-crop insect investigations.

(8) Work on insects injurious to vegetable crops.

(9) White-fly investigations.

(10) Investigations of insects in their direct relation to the health of man and domestic animals.

(11) Work on scale insects.

(12) Work on insects injurious to stored products.

(13) Experimental work with insecticides.

(14) Investigations of insects affecting tobacco.

(15) Inspection work.

- (16) Work in bee culture.
- (17) Work in silk culture.
- (18) Miscellaneous investigations, the exhibit at the Jamestown Exposition, and other work.

WORK ON THE MEXICAN COTTON BOLL WEEVIL AND OTHER INSECTS AFFECTING COTTON.

The work of the Bureau of Entomology on the cotton boll weevil was continued during the fiscal year 1907 under Mr. W. D. Hunter, to some extent along the lines of previous investigations, though new features that have an important bearing on practical control were given attention. In the case of a pest that causes an annual loss of about \$25,000,000, falling upon a single industry restricted by climatic conditions to less than one-fourth of the area of the United States, it is evident that the very fullest knowledge of its life history and habits must be obtained and disseminated. Naturally, any means of control must be based upon this information. Partially successful means of control or means of use in restricted regions or under special conditions can not be considered as satisfactory. Continued efforts must be made until the best possible means of control are devised and tested in the field. The problem caused by the boll weevil is made more difficult and more work is required by the fact that the insect is adapting itself to new conditions and changing its habits in ways that interfere seriously with the present means of control. The work conducted by the Bureau of Entomology has been classified under the following heads.

EXPERIMENTAL FARMS.

As in the preceding year, the Bureau has conducted a number of large-scale field experiments. The experimental farms were of from 10 to 65 acres in extent and located in various regions where the weevil problem assumes local aspects. They were primarily of an experimental character, but incidentally of great value as practical demonstrations of the success that may be attained by following the recommendations that have been made by the Bureau. Careful studies and records were made and valuable practical information obtained. The season was abnormal and the necessity for the continuance of such work through a series of years in order to obtain exact information was again demonstrated. The experimental farms were located in the following counties in Texas: Robertson, Navarro, Travis, Dallas, Henderson, Karnes, Hunt, Bowie, Denton, Kerr, Wood, and Llano; and in the parishes of De Soto and Vernon, in Louisiana. Similar work was also conducted near Ardmore, in Indian Territory. The total area covered by these experiments was 378.5 acres. The work was arranged, as has been the case in the past, under a contract which gave the Department practically absolute control of all details. The total cost of this work to the Department was about \$800.

In addition to the work under contracts, nearly 500 acres were utilized under a merely cooperative arrangement with farmers in many localities, without any expense whatever to the Department.

SPECIAL FIELD EXPERIMENTS.

In the last annual report attention was called to the necessity for a large-scale experiment in the fall destruction of cotton plants. This practice has been tested on a small scale in many localities and its efficiency has been demonstrated. Nevertheless, there are practical difficulties in the way of a general following of the practice by farmers, who have been slow to take it up. It was therefore decided to conduct a larger demonstration than had been possible in the past. To do so a locality was found in Calhoun and Jackson counties, in Texas, where 25 or more farmers had an aggregate of 410 acres of cotton. This locality was isolated completely from other cotton. On one side was the Gulf of Mexico, on another a broad arm of the Gulf, and on the remaining sides large stretches of swamp lands. The nearest cotton was about 10 miles distant. An agent of the Bureau of Entomology succeeded in inducing all the farmers in this locality to destroy the cotton stalks early in October. Their work was done under contract, which gave the Department authority to see that the work was done quickly and well. During the first ten days in October all of the cotton was uprooted and burned. Examinations that have been made this season show the very great importance of the work done during the preceding fall. Up to the present time (July, 1907) there has been virtually no weevil infestation in the area where the cotton was destroyed and where the same crop was planted this season under the usual conditions. In fact, for some time it appeared that the weevils had been absolutely exterminated. However, in June it was found that a very few of the insects had come from hibernating quarters in a hedge near one of the cotton fields. This resulted in an extremely slight local infestation. A large area of cotton growing across the bay, at a distance of about 15 miles, has been used as a check on the experiment. In the case of this check, the cotton stalks were not destroyed until December and January, which is the usual practice in that region. The plants were uprooted and destroyed only as an incidental step in the preparation of the land for planting. On this area in June an infestation of at least 50 per cent of the fruit on the plants was found. The prospects of making a crop are consequently very small, while on the experimental area it is scarcely possible that any conditions can now interfere with making a very large crop. The early destruction of the plants practically eliminated the boll weevil as a factor in cotton production for this season. In addition to the practical demonstration just referred to, a large amount of data was obtained from practical cotton growers in many localities who have practiced the fall destruction of plants. All of this information will be embodied in a special report that will be issued during the present season.

It has frequently been urged that it might be possible to control the boll weevil more effectively by late planting of cotton than by the early planting which has been recommended by the Bureau of Entomology, and which has come to be generally practiced. It has been supposed that the lengthening of the hibernation period by deferred planting rather than by the fall destruction of plants would be as effective as that process and much easier to place in operation on the average farm. In order to test this matter fully a number of

special field experiments was arranged. These experiments were located at four places in as many agricultural provinces in Texas and at one place in Louisiana. The latter work was done in cooperation with the Louisiana crop-pest commission. The results of these experiments have been referred to in an article in the Yearbook of the Department for 1906. In brief, the fallacy of late planting was proven beyond any possible doubt. In not one of the four cases in Texas was any appreciable amount of cotton produced. The plants grew well, but the boll weevil appeared in such numbers as to destroy practically all of the crop. The fields used were extremely isolated, and there could have been no invasion of weevils from outside. It is therefore certain that the insects may survive long enough to attack cotton planted as late as the middle of June and destroy it. This work is a complete refutation of the theory that has been proposed, and the publication of the results will undoubtedly prevent the useless expenditure of money by many farmers.

WORK ON THE CONTROL OF THE WEEVIL DURING THE HIBERNATION SEASON.

Many details connected with the proper procedure in the fall destruction of the cotton plants can only be determined by special field experimentation. One of these points is the approximate time in the fall when the work should be done. In order to obtain the necessary information the Bureau of Entomology conducted three large experiments at Victoria, Calvert, and Dallas, Tex. At each of these places large cages (20 by 50 feet) were erected over cotton growing in the fields. Each of these cages was divided into ten sections. Early in October the plants were removed from one of the sections at each of the places mentioned, while the weevils were allowed to remain. In order to make the results more satisfactory numbers of weevils collected in the field were placed in these sections immediately after the removal of the plants. In all, over 70,000 weevils were utilized. At regular intervals subsequent to the removal of the plants from the first cage, other sections were treated likewise. In the cage experiments, of course, accurate notes have been made regarding the number of weevils that have survived the winter. In this way it will be possible to determine exactly what benefit a farmer may obtain in southern, central, or northern Texas by the destruction of the cotton plants at various dates through the fall and winter. This work will give the farmers exact information as to what they may accomplish by the destruction of the plants at different times in the fall and will probably emphasize the supreme importance of the earliest possible destruction.

As has been the case in the past, a considerable fund was set aside by the Bureau of Entomology as a reserve to be used in the eradication of isolated colonies that may be expected at any time. With the increase in infested area and the proportionate increase in the amount of farm commodities shipped from it to regions where the boll weevil does not occur, the danger of the occurrence of isolated colonies has recently increased enormously. In one instance an isolated outbreak was completely eradicated by the Louisiana State authorities, and there is no reason why similar results might not be obtained in case, for instance, a colony should be found in South Carolina. If it were discovered in time energetic work would save hundreds of thousands of dollars to the State concerned.

WORK DIRECTED TOWARD THE PRACTICAL UTILIZATION OF THE PARASITES AND PRE-
DACEOUS ENEMIES OF THE BOLL WEEVIL.

By all means the best method of controlling injurious insects is the encouragement of the natural checks provided for them—that is, parasites and predaceous enemies. Most conspicuous examples of effective entomological work have involved the use of this method. In the case of the boll weevil there are many difficulties. One of these is that the insect works within the tissues of the plant in all stages, except one, so that it is better protected from its enemies than many others. Another obstacle lies in the fact that the boll weevil is a new insect in the United States, having left behind the parasites that control it in its original home, and until very recently there has not been sufficient time for the native parasitic agencies to come into operation. An important line of work undertaken in the fiscal year 1907 was a careful study of this matter. It was first necessary to examine many thousands of squares and bolls from various localities in the infested area to determine what different parasites and predaceous insects were present in different quarters. It was also necessary, when parasites were found, to ascertain the source from which they came. This involved much careful investigation of insects related to the boll weevil infesting various plants growing in and about cotton fields. It was found that fifteen different insects which attack the boll weevil in its immature stages are now at work to a greater or lesser extent in the infested territory. The number is undoubtedly increasing, and will continue to do so as the boll weevil invades regions where parasites of other weevils are present. That the matter is not one of small importance at present is indicated by the fact that in a field near Waco, Tex., it was found that fully 40 per cent of the weevils had been killed by the combined work of several species of parasites.

Practical results of the work on parasites are already in sight. Among them may be mentioned the feasibility of the collection and propagation of parasites and their distribution in regions where the same species are either absent or present in but small numbers. In an experiment performed in the summer of 1906 a number of parasites were taken from Waco, Tex., and liberated in a cotton field near Dallas, Tex. Apparently by this means the mortality rate due to parasites was raised in a few weeks by about 9 per cent. Another practical point that has been brought out is that, by the elimination of weevils related to the boll weevil by the destruction of their food plants in or about cotton fields, the farmer may force the parasites to transfer their attention to the boll weevil. It was, of course, only after very careful studies of the weevils of various species occurring about cotton fields that the information necessary for this procedure could be obtained. Now, however, as a result of the work that has been done, it may be pointed out what plants are infested by weevils the parasites of which may attack the boll weevil and the exact time when these plants should be cut down. Other practical points and field tests remain to be undertaken.

The studies of the parasites of the boll weevil have brought to light many matters that have a general bearing on the control of injurious insects everywhere. The results obtained up to the present time have been submitted for publication in a bulletin which will shortly appear.

In addition to the parasites referred to in the preceding paragraphs, at least one very important predaceous enemy of the boll weevil has been found, namely, the native fire ant, *Solenopsis geminata*. This insect is not to be confused with the Guatemalan ant. It occurs throughout the cotton belt and has been found to be a very important factor in controlling the boll weevil in its original home in Central America. In this country it is rapidly acquiring a habit of feeding upon the boll weevil. In order to determine exactly what work is being done by this ant and the conditions most favorable for it, large numbers of squares were examined from cotton fields in various parts of Texas. The importance of the ant's work was clearly shown as a result of these examinations. At Beeville, Tex., for instance, in August, 1906, out of 874 weevil stages found, 684 had been destroyed by ants. The studies conducted showed the comparative effectiveness of control by the ant in various localities in Texas and Louisiana, and also the special conditions in any one locality which favored the work of the ant. Information of this kind in many cases can be made of practical use in the location and management of cotton fields. The whole matter will receive careful attention in a publication of the Department that is about to be issued.

MISCELLANEOUS WORK.

In addition to the principal lines of investigation referred to, considerable work has been necessary to determine the status of the boll weevil at different times. There is a constant and legitimate demand for information as to the probable damage by the pest, and reasonably safe predictions may be made from the field examinations early in the season, provided they can be extended over sufficient territory. During the fiscal year 1907 several general examinations were made. These involved the work of eight or ten entomologists for about ten days' time. The first examination was made in June, and the results which were published indicated clearly that the damage to be expected from the boll weevil during the year would be much less than normal. This prediction was verified later by the very large crops produced in the infested territory.

There is also great demand for information regarding the additional territory that becomes infested by the boll weevil from time to time. To supply this information men were placed in the field to determine the exact extent of the dispersion of the insect, and the results were expeditiously published in the form of maps.

As in preceding years, a number of preparations designed to destroy the boll weevil were tested at the laboratory at Dallas. Many mechanical devices were also investigated. This line of work is absolutely necessary to refute the claims of overenthusiastic persons and thereby to prevent the useless expenditure of money by farmers. Many addresses were delivered at meetings of farmers, and many special articles were written for agricultural papers on matters of local or general concern. As usual, a large amount of information was disseminated through correspondence.

The work in cooperation with State experiment stations was continued. One man was detailed to the Texas experiment station and three were detailed to the crop-pest commission, which is virtually a part of the experiment station organized in Louisiana.

WORK ON THE COTTON BOLLWORM AND OTHER COTTON INSECTS.

The bill appropriating for the expenses of the Department of Agriculture for the fiscal year 1907, in its emergency appropriations, did not contain the same specific mention of the cotton bollworm as did that of the previous year, and in fact the work of the previous year had practically completed the investigation. Seven demonstration experiments, however, were carried on, based upon the information gained by the work of the previous years—five in Texas and two in Louisiana. The results of the entire work have been carefully summed up in Farmers' Bulletin No. 290, and it seems obvious that by following carefully the recommendations given in that bulletin cotton planters can reasonably expect to escape serious damage by this destructive insect.

The incidental work on other cotton insects has also been carried on in cooperation with the Texas State Agricultural Experiment Station. An assistant has been stationed at the State college, as in the previous year, carrying on certain experimental work with the cotton insects of minor importance, and particularly with the cotton aphid, as indicated in the last report.

WORK ON THE GIPSY MOTH AND BROWN-TAIL MOTH.

As indicated in the last annual report, under the head of "Proposed work for the fiscal year 1907," headquarters for this work were established in Boston; Mr. D. M. Rogers was placed in charge of the work, a large force of laborers was engaged, and energetic work was begun immediately when the appropriation became available. Under the terms of the appropriation, the efforts of the Bureau have been directed toward preventing the further spread of the gipsy moth and the brown-tail moth. As previously shown, there is a radical difference in the possibilities of effective work to prevent the spread of these two insects. The brown-tail moth is a ready flier, and at the time the work began had already covered a great extent of territory, reaching from Amherst, Mass., to a point high up on the Maine coast. At the time of its annual flight it is carried by prevailing winds, often for hundreds of miles from its place of birth, and an effort to prevent its spread seems almost hopeless except by the active cooperation of every property holder in the infested territory. The campaign against this insect has therefore been begun as an educational campaign, and the importance of local effort has been shown as forcibly as possible. An illustrated farmers' bulletin has been published and distributed widely throughout the infested territory, and State and local officials have been urged to do everything in their power to induce the destruction of the winter nests. The States of Maine, Connecticut, Rhode Island, and New Hampshire, in addition to the State of Massachusetts, have passed laws based upon the Massachusetts law and have made appropriations for State work. While these appropriation laws include the gipsy moth with the brown-tail moth, the brown-tail moth is receiving from the outlying States perhaps more attention than the gipsy moth.

The conditions are quite different with the gipsy moth. The female can not fly, and the species is distributed by the caterpillars, which, spinning down from trees overhanging the roadsides, are

carried long distances by automobiles, carriages, trolley cars, and other vehicles, and shorter distances by pedestrians. The species was known to occur, at the time when work was begun, in a rather definitely restricted region, including the eastern portion of Massachusetts, one locality in Rhode Island, one in Connecticut, and several in the southeastern portion of New Hampshire. Within this territory the caterpillars were to be found in the forest land, in public parks, in orchards, and upon the street trees of cities and roadside trees in the country. Two methods of work were obvious—one to work upon the outer border of the infested territory and gradually retract the line of spread toward the center. This method, however, was deemed inadvisable for the reason that the principal spread is surely from the interior to new points beyond the line by means of vehicles, as just indicated. Therefore the second method was adopted, which consists in working along the thoroughfares leading from the most seriously infested localities, and this work was prosecuted in the summer time and autumn months of 1906. A strip of about 100 feet wide on each side of the road was cleared up; all underbrush was cut out; poor trees were removed, and the remaining ones were pruned; all débris was burned. Such work has been done during the year in Malden, Melrose, Saugus, Wakefield, Lynnfield, Peabody, Woburn, Lexington, Burlington, Waltham, and Belmont—in all about 65 miles of road, 100 feet on each side.

In the fall of 1906, after the gipsy moth had deposited its eggs, selected men were taken from the force and sent over the 100-foot strips, treating all egg clusters with creosote oil. This work was continued until May, 1907, when the eggs began to hatch. During the latter part of April and the first part of May the trunks of the trees in all of these strips were banded with sticky bands to prevent the ascent of caterpillars which might have hatched from broken egg clusters or which might come from the territory back of the 100-foot strips. The same trees were also banded with strips of burlap above the sticky bands, so that such caterpillars as might hatch in the trees above the bands could be caught in the burlap hiding places.

About the first of June spraying operations were begun. Four spraying machines operated by gasoline engines were used, and the spray consisted of arsenate of lead in the proportion of 10 pounds of poison to 100 gallons of water. This spraying continued until the close of the fiscal year and later.

The work was done entirely in the State of Massachusetts, since outlying colonies have all been shown to have originated from the section included in this work. But in addition to the Massachusetts work, an arrangement was made with the authorities of Rhode Island whereby the force of men employed by that State, on the lapsing of the Rhode Island appropriations, was transferred to the Bureau on July 23, 1906. These men were kept at work until May 15, 1907, and on the passage of the Rhode Island appropriation bill were retransferred to State authority on May 16. This force examined every tree and most of the shrubbery and thousands of buildings and fences in the city of Providence; destroyed all the gipsy-moth egg clusters that could be found, treated all trees having cavities which could be used as hiding places for the caterpillars, located the egg clusters, and cleaned up all around the infested places in Cranston, Johnston, North Providence, East Providence, Pawtucket, and

Barrington. The work was so well done that it is difficult at this date of writing to find a gipsy-moth caterpillar in the State. At the beginning of the work the gipsy moth was thought to be confined to the city of Providence, but as it progressed it was found in the six additional localities above mentioned. Some scouting was done in northeastern and southern Rhode Island, but no gipsy moths were found; the brown-tail moth, however, was discovered in Woonsocket, Cumberland, Central Falls, and Pawtucket.

A small gang of men was sent to Connecticut March 20, 1907, to scout in the territory about the gipsy-moth colony at Stonington. A thorough examination was made of this town and some scouting was done in the towns of Groton and North Stonington, but no insects were found except in the immediate vicinity of the territory already known to be infested, which is about 1 square mile in area and is being cared for by the State.

Early in the fall of 1906 scouting operations were begun in New Hampshire, at the southeastern corner of the State, where the gipsy moth had been discovered the previous year. This scouting was continued until June 30, 1907, and the gipsy moth was discovered in 35 of the 77 towns that were inspected.

In November, 1906, scouting was begun in Maine, and was continued until May 25, 1907. Thirty-five cities and towns were examined, and the gipsy moth was discovered in eight. With the exception of a single egg cluster found at the Soldiers' Home at Togus, Chelsea, Me., the known infestation is confined to the extreme southwestern portions of the State, in the towns of Kennebunkport, Kennebunk, Wells, York, Kittery, Eliot, and South Berwick.

As above stated, all of the New England States in which the gipsy moth is known to occur have appropriated funds and have enacted laws directed toward the gipsy moth and the brown-tail moth during the past winter. Maine appropriated \$30,000 for 1907 and \$30,000 for 1908; New Hampshire appropriated \$25,000 for the two years 1907 and 1908; Rhode Island and Connecticut each appropriated \$10,000, or so much thereof as may be necessary.

The laws of the infested States, if enforced, will probably be effective in keeping the pest in check in the residential sections, but the forest lands will suffer greatly unless sufficient appropriations can be secured to care for them, or unless the parasites imported from Europe, which will be mentioned in a later section of this report, multiply sufficiently to reduce the insects to a minimum in such sections.

The work that has been done under the auspices of the Bureau has been careful and thoroughly effective. The experienced superintendent of the Massachusetts State work, Mr. Kirkland, states that he has never seen more careful and thorough work done.

IMPORTATIONS OF USEFUL INSECTS.

- The work of the Bureau in importing useful insects has been devoted almost entirely to continuing the importation of parasites of the gipsy moth and the brown-tail moth. During the early part of the fiscal year packages containing parasitized caterpillars of both species continued to be received from European agents. These

were cared for, as stated in the last report, in the laboratory at North Saugus, Mass. Parasites of a large number of species were reared; some were liberated in the open, and others were studied in confinement in larger or smaller breeding cages. Following the experience of the previous winter, when good results were obtained by the importation of large numbers of the hibernating nests of the brown-tail moth, from which in the early summer were reared parasites belonging to species which infest both the gipsy moth and the brown-tail moth, during the winter of 1906-7 more than 111,000 hibernating nests of the brown-tail moth were brought over from different portions of the European range of this species. These were placed in specially constructed cages, and from them large numbers of parasites were reared. They issued mainly during the month of May. As it happened, the month of May in New England, as well as in other parts of the United States, was phenomenally cold and wet. As a result of this unlooked for condition very many of the parasites refused to leave the nests until they were so weakened as to be unable to survive the close confinement and careful scrutiny to which they were necessarily subjected in order to eliminate the danger of introducing secondary parasites. As a result a smaller number of this group of parasites (*Pteromalus*) was colonized than in the summer of 1906, but 40,000 specimens were put out in several localities, the principal colonies consisting, respectively, of 13,000, 11,000, and 7,000 individuals.

In this important work with the introduced hibernating nests of the brown-tail moth it was early found most difficult to preserve the health of the laboratory assistants. The irritating and poisonous hairs of the brown-tail moth larvæ, of which the nests are full, soon penetrated the skin of the assistants handling them, entered their eyes and their throats, and the atmosphere of the laboratory became almost filled with them. It was necessary that the laboratory rooms should be kept thoroughly closed; double windows and screens were used, and the doors to the rooms were darkened in order that a possible secondary parasite becoming accidentally liberated should have no chance of escape. This made the rooms very warm and increased the irritating effect of the larval hairs. Some of the assistants employed could not stand the work and resigned. One of the best and most experienced was induced to continue the present year only upon promise that he should be relieved from this especial class of work. Spectacles, gloves, masks, and even headpieces were invented to avoid this difficulty, but these, while greatly increasing the suffering from heat, were not entirely effective. The most serious result of this trouble was the breaking down in health of Mr. E. S. G. Titus, in charge of the laboratory, who was obliged to resign in May, 1907, on his physician's advice, in order to save his life. The difficulty in Mr. Titus's case was the intense irritation to his lungs from the entrance of the barbed hairs. Mr. W. F. Fiske was sent from Washington to replace him, and has since had charge of the laboratory. New methods of handling the brown-tail nests have been invented, and it is hoped that this difficulty will be measurably obviated in the future.

The Chief of the Bureau visited Europe again during May and June, 1907, engaging new voluntary assistants among European entomologists and establishing a very effective corps of observers in Russia, a country which has not before been called upon. At Kief,

Kisheneff (Bessarabia), and Simferopol (Crimea) stations were established and much good and new material has been sent in. At Kief a large experimental orchard was engaged for scientific observations and for the purpose of collecting and caring for parasitized larvæ in large numbers. New collections were made in Germany, and an experimental station was established near Rennes, in France. Observers in many parts of Europe were found who have taken a deep and enthusiastic interest in the experiment, and as a result of the trip so much material has been received at the North Saugus laboratory as to demand a great extension of laboratory space.

Especial efforts were made during the late spring and early summer of 1907 to arrange for the importation of larger numbers of the egg parasites of both species, and to introduce in living condition the important parasites of the genus *Apanteles*, which, according to the writer's field observations, are among the most important of the European enemies of the gipsy moth. Previous importations of these parasites had failed, owing to the fact that the parasites emerged and died on the journey. The present year, however, specific directions were given to agents to send in young larvæ of the second age, and by this means living specimens of the parasites in considerable numbers have been reared at North Saugus. These on issuing laid their eggs in the gipsy-moth larvæ in their first stage. From these caterpillars were secured the cocoons and adults of a second generation, which was reared through all of its stages on American soil. It is hoped to repeat this experience on a more extensive scale next year, and thus to secure a very large number of the adult parasites for colonization.

Moreover, the important experiment has been tried this summer of rearing from the imported brown-tail nests a very large number of caterpillars which gave out in their later growth a second lot of parasites entirely different from those reared in May from the very young hibernating larvæ. Among these were at least two species of the important parasites of the genus *Apanteles*.

Another important result of the work of the early summer is the rearing from imported brown-tail nests of a parasite of the genus *Meteorus*. From the larger caterpillars a second generation has been reared after a very brief interval, the cocoons appearing in about ten days in cages in which the adult parasites were confined with their host insects. This indicates a very short breeding period during the summer time, and although this parasite has not been reared in great numbers its quick breeding indicates that it is a very desirable introduction. Probably the same species was occasionally found in boxes in which the nearly mature brown-tail caterpillars were shipped, and a few emerged from some of these caterpillars, which arrived alive and in apparently a healthy condition. After the parasite emerges the larger caterpillars seem as though they were not fatally affected by the work of the parasitic larva, but all have died without transforming. The species of this genus *Meteorus* on occasion may become very effective; a native species, for example, has been known to destroy 90 per cent of the larvæ of a native moth infesting the western pines.

In addition to the sending of brown-tail hibernating nests above referred to, during the fiscal year ending June 30, 1907, there was received from Europe a total of 1,375 boxes containing the matured

caterpillars and pupæ of the gipsy moth and the brown-tail moth. Of these, 872 boxes of the brown-tail were received during June, 1907, and 82 of the brown-tail and 425 of the gipsy during July and August, 1906. The percentage of parasitism varies considerably, according to the different localities from which the nests were sent, but it must be remembered that in these European localities the percentage of parasitism is constantly fluctuating, being smaller in some years and almost exterminative in others. A part of the parasites sent over do not emerge from the caterpillars or pupæ until after they arrive at North Saugus; others are found in the boxes in the pupal condition, and a few, especially toward the latter part of the season of sending, transform into adults and die on the journey.

Of these parasites, about 90 per cent have been tachinid flies, and perhaps 12 species have been reared from the two host insects, most of them being common enemies of both species. About 40 per cent of these flies emerge as adults at nearly the time of the emergence of the moths of the species which they attack, while the remainder pass the winter in the pupal condition, emerging the following spring. Seventeen hundred adult tachinids were colonized in July and August, 1906, and more than 2,000 during June, 1907. It is now obvious that a very large number will be on hand hibernating during the winter of 1907-8, and the problem of caring for them is a serious one. They are considerably parasitized by hymenopterous, secondary parasites, so that it will be necessary to keep them well protected, at the same time under conditions as near the normal as possible. At the close of the fiscal year between 6,000 and 7,000 puparia were already on hand. With one of the smaller species of tachinids breeding experiments were very successful, and the species reproduced freely under these conditions, indicating that it will be the part of economy to handle it in this manner, liberating only after having bred large numbers.

The large predatory beetles of the genus *Calosoma*, referred to in previous reports, have been successfully introduced in considerable numbers. *Calosoma sycophanta* was discovered in several of the field colonies in the spring of 1907, having established itself, survived the winter, and reproduced. It is a valuable importation, but whether it will prove in itself sufficient to reduce the numbers of the gipsy moth and the brown-tail moth to an appreciable extent is undetermined.

In the report for last year the writer drew particular attention to two species of the genus *Pteromalus*, small parasites of the superfamily Chalcidoidea. Some 60,000 were reared in the early summer of 1906, and the great majority of them were liberated. That the species has established itself, at least temporarily, has been shown by the fact that specimens were bred in the spring of 1907 from nests collected in colonies of the year before. Throughout a considerable portion of the territory directly north of Boston, within which all of the larger colonies were planted last year, the caterpillars of the brown-tail moth died very generally from a fungous disease, and as a result there was a scarcity of the hibernating nests. Therefore, it was not considered desirable to collect for breeding purposes many of these nests, and it is confidently expected that the species will be found more abundantly in the collections of nests made next winter.

Several new colonies have been planted in quite widely separated localities.

The difficulty of determining the exact names of these European parasites, nearly all of which are very common members of the European fauna, is scarcely to be believed. The two species of *Pteromalus*, for example, mentioned in the last report have been a source of great difficulty. The writer was unable to find them represented in the large museums at Vienna, Dresden, Berlin, Brussels, and London, nor did they occur in the type collections of Ratzeburg at Eberswalde, where, on account of that writer's important work on the parasites of European forest insects, one would naturally expect to find them. At last, in the Museum of Natural History in the Jardin des Plantes at Paris, specimens of both species were found that had been reared many years ago by the French entomologist Sichel and had been named for him by the eminent authority on parasites, Arnold Foerster, of Germany. They will, therefore, in the future be known definitely as *Pteromalus nidulans* Foerst. and *Pteromalus egregius* Foerst.

OTHER IMPORTATIONS.

What may prove to be an important egg parasite of the imported elm leaf-beetle has been discovered in France, and through the courtesy of two French correspondents, Dr. Paul Marchal, of Paris, and Mr. Ch. Debreuil, of Melun, egg-masses were sent to this country in the hope of establishing the parasite on this side of the ocean. Both sendings, however, were started too late in the year, and the parasites issued during the journey, dying before they could be liberated.

As happened last year, several species of European Coccinellidæ, beneficial in habit, were imported and liberated in the vicinity of the parasite laboratory at North Saugus, Mass. No progress is to be reported in regard to the older importations, the status being practically that of a year ago. During the last European trip of the Chief of the Bureau, arrangements were made for the importation of the European enemies of the codling moth, and these should begin to arrive the coming autumn.

EXPORTATIONS OF USEFUL INSECTS.

The official entomologists of European countries have been so helpful to the United States Department of Agriculture in assisting in the various importations of beneficial insects from abroad, and especially in the work on European parasites of the gipsy moth and brown-tail moth, in all cases refusing material compensation, that it is a pleasure for the Bureau to find that it can be of assistance in the way of return favors of like character. During the past year various exportations of certain important parasites of *Diaspis lanatus*, an injurious scale-insect found upon peach, cherry, pear, lilac, and other trees and bushes in the United States, but which is much more injurious in southern Europe, where it attacks the mulberry upon which the prosperity of the silk industry depends, have been made to Italy, where they have been received and cared for by Prof.

Antonio Berlese of the Royal Station for Agricultural Entomology at Florence, and by Prof. F. Silvestri at Portici. Several species of these parasites have been bred in Italy, and it is the expectation of our Italian correspondents that they will be of assistance in holding the mulberry scale in check.

An even more interesting experiment of this sort has been entered into in order to assist the French Government to stamp out a dangerous disease of the dromedary in Algeria. The disease in question is caused by a trypanosome inhabiting the blood, and it is conveyed by tabanid flies. The natural enemies of the tabanid flies in Algeria are not effective, owing to a decidedly diverse period of abundance in the two forms. The United States Department of Agriculture has therefore been appealed to for advice in regard to the sending of American species inimical to the tabanids, which may possibly develop in Algeria in such a way as to control the disease-carrying species. Efforts were made toward the close of the fiscal year to send to France for immediate transportation to Algeria large shipments of *Monedula carolina*, a sand-digging wasp common in the Southern States and which is an effective enemy of American tabanids.

INVESTIGATIONS OF INSECTS DAMAGING FORESTS.

The work on forest insects carried on under the supervision of Doctor Hopkins, the entomologist in charge, has been largely in the line of continued work on the projects mentioned in previous reports. Very satisfactory progress has been made, both in acquiring and diffusing information of practical value to the forest interests of the country.

WORK ON THE INSECTS THAT PREVENT FOREST REPRODUCTION.

It was found that the principal damage by insects to forest reproduction is caused by certain scolytid beetles which bore into the new cones of the western yellow and other pines and prevent the normal development of the cone seeds. Certain caterpillars belonging to different genera are also found to destroy the new cones or the seed in the old cones of pine and fir; and certain seed parasites of the genus *Megastigmus* often cause an entire failure of the seed crop of the Douglas fir, the balsam fir, and other species. The combined depredations of these insects frequently destroy the seed crop and prevent natural reproduction. There are also numerous enemies of the saplings, including the destructive white-pine weevils, which contribute to the failure of young growth to replace the old. Much has been learned concerning the life histories of these insects, and some of the results have been published in Circular No. 90 of the Bureau and elsewhere.

WORK ON INSECTS INJURIOUS TO FOREST PRODUCTS.

The lumbermen and manufacturers in this country, and the consumers in other countries, of certain export material, have shown a great deal of interest in recent years in an insect injurious to crude, manufactured, and finished products. Especial attention has been drawn to the insects affecting seasoned stored and finished hardwood material and the woodwork in dwellings and other buildings. These injuries are caused by a class of insects called powder-post

beetles and are very severe. During the year data have accumulated concerning the habits and life histories of these insects, and much has been accomplished toward the determination and practical application of successful methods of control. These involve the proper management of the material to prevent injury, the destruction of worthless infested material at the proper time to destroy the insects, and the proper and liberal use of pure kerosene both as a destructive and preventive agent—all of which, however, must be adjusted to meet the requirements of the different kinds of wood, classes of material, and species of insects involved. Circular No. 55 gives some preliminary information on the subject, and a special bulletin will be published as soon as some of the important details of the work have been completed.

WORK ON INSECTS OF THE BLACK HILLS NATIONAL FOREST.

The work on insects of the Black Hills National Forest was continued during the season of 1906 mainly in completing the study of the seasonal history and habits of the Black Hills beetle and observations on the extension of its ravages; also in the testing of a recently invented tool for the removal of infested bark from standing timber.

Methods had already been recommended by the Bureau to the Forest Service for the control of the ravages of the beetle. These measures would have been effective if carried out. The depredations, however, had extended over such a wide area and such a large proportion of the material was infested that at least 200 men, working several months, would have been required and a much larger expenditure of money, in addition to that derived from sales of timber, than was practicable with the available force and funds at the disposal of the Forest Service; therefore the work was stopped. Unless the necessary radical and rather expensive methods now required are adopted, it seems useless to expend the small amount of money available; and unless some natural enemy appears within the next year or unless radical artificial measures can be adopted at once, practically all of the merchantable timber of the entire forest will be destroyed.

WORK ON BENEFICIAL FOREST INSECTS.

A thorough study has been made of the natural enemies of forest insects and a large amount of material has been brought together; interesting and important facts have been ascertained concerning their life history and the possibility of their practical use. The knowledge of this phase of the subject has advanced to a stage where much of important practical value is available for immediate utilization in the introduction of natural enemies or in the adjustment of forest management and business methods for the protection and promotion of these natural enemies.

OTHER WORK.

Studies have been made on the relations of environment to injury to forest trees by insects, such, for instance, as the relation of storm-felled trees to multiplication of the insects; the relation of soil and climate to insect depredations, and the relation of drought to the

same subject. The relations of insects and forest fires in the destruction of forests has also claimed especial attention. The contributing of insect-killed timber to the starting and spread of forest fires is an important subject, and studies made indicate that the damage attributed to fire alone may be directly chargeable to insects, although not necessarily in all cases.

A great deal of work has been done on the bark weevils of the genus *Pissodes*; on insects affecting hickory and ash; on insects affecting the black locust; and in the forests of the Northwest, the Pacific coast, the Southwest, the northern section of the Rocky Mountains, as well as in the South and East, special insects have been studied and special problems have been under the observation of field agents. In cooperation with the Forest Service, special explorations have been made of National Forests and private forests, the knowledge possessed by forest rangers being utilized in a number of instances.

Systematic and economic studies of special groups of forest insects have been begun and carried on, and during the winter time field assistants returning to Washington have been engaged in the systematic investigation of problems relating to such special groups of insects.

INVESTIGATIONS OF INSECTS DAMAGING DECIDUOUS FRUIT TREES.

The work on insects damaging deciduous fruit trees has been in the main a continuation of the investigations already in progress at the close of the last fiscal year, though additional projects have been undertaken, and the tests of the lime-sulphur washes and other insecticides for the San Jose scale have been concluded.

FIELD STATIONS.

The plan of maintaining field stations in parts of the country devoted to the growing on a large scale of deciduous fruits has proved to be a most excellent one, and in this way it has become possible thoroughly to study under perfectly normal conditions the insects which are under investigation, and to conduct tests of remedies on a commercial scale. The work at the respective field stations in the study of a given insect pest and in tests of insecticides, so far as is possible, is carried out according to a uniform plan, so that the results are entirely comparable and calculated to show any variations in the life and habits of the species and what changes, if any, should be made in the use of remedies on account of climate, location, etc.

The field station at North East, Pa., has been continued and two additional men have been assigned to assist the field agent in immediate charge. This increase in force became necessary on account of taking up additional work with certain grape insects to be presently mentioned.

The field station which was maintained during 1906 at Myrtle, Ga., for the study of peach insects was discontinued at the close of the growing season for that year, and the agent there located was transferred in the spring of 1907 to Olden, Mo., to continue investigation of peach insects in the peach-growing regions of the Ozarks.

The field station at Nebraska City, Nebr., for codling-moth experimental work, maintained during 1906, was also transferred to Olden,

Mo., in the spring of 1907, where better facilities are afforded for work on this insect by reason of a larger and more convenient orchard acreage. The uniting of the two lines of work at Olden also resulted in a more complete equipment of the laboratory and of spraying apparatus.

Demonstration spraying in the control of codling moth and apple diseases in cooperation, as during the last calendar year, with the Bureau of Plant Industry of this Department, was begun in the spring of 1907 in southeastern Nebraska and in the Ozark regions of Missouri and Arkansas and in Virginia.

The practically complete destruction of the fruit crop in Nebraska and Missouri by late spring frosts after the work was well under way necessitated an immediate change of plans, and the codling moth experimental work for the Middle West was transferred to Siloam Springs, Ark., where a sufficient apple crop was found. The peach insect investigations in the Ozarks were, on account of the lack of fruit, abandoned. A temporary field station has been located in southern Ohio, where important observations have been made on various deciduous fruit pests.

CODLING MOTH INVESTIGATIONS.

The experimental work on the codling moth, beginning May 1, 1906, at Nebraska City, Nebr., was continued to the close of that season, and embraced a thorough life-history study of the insect for that section, and the spraying of a series of plats to show the relative value in controlling the insect of from one to six applications of spray made at various times during the season. The codling moth investigation has been continued, beginning with the spring of 1907, along about the same lines as for 1906, though considerably extended. A detailed life-history study of the insect and investigations of its parasites, etc., with tests of sprays designed to show the number and times of applications which may be most effective, are under way. The transfer of work to Siloam Springs, Ark., on account of the destruction of the fruit crop at Olden, Mo., will not, it is believed, seriously impair the investigations planned.

This insect is also being investigated at the northern field station at North East, Pa., along approximately the same lines as in the South, and also in the vicinity of Washington, representing a more central latitude. This species will also be made the subject of special investigations, beginning the first of the fiscal year 1907-8, on the Pacific coast, as explained under plans for that year.

In addition to the purely experimental work on this insect above indicated, this Bureau, in cooperation with the Bureau of Plant Industry, is carrying out demonstration sprayings in control of the codling moth and apple diseases. This work, under way at the close of the last fiscal year, was continued during the remainder of the season of 1906, and included spraying apple orchards on a commercial scale in several localities in southeastern Nebraska, in Missouri, and Arkansas, the principal results of which have been published in *Farmers' Bulletin* 283. The work in general resulted in a much greater reduction of losses from codling moth than the growers in these respective sections were accustomed to obtain, and also has

resulted in a great improvement in the methods of preparing and applying sprays on the part of orchardists.

The demonstration spraying planned for the spring of 1907 for the Middle West was much modified on account of the loss of the fruit crop in southeastern Nebraska and Missouri, and the work has been restricted to several points in Arkansas. Similar work, however, is being done in one locality in Virginia, in southern Ohio, and also at North East, Pa. These necessary changes of location in the Middle West interfered with the timely application of the first one or two sprays, but it is hoped that the final results will not be seriously modified.

PLUM CURCULIO INVESTIGATIONS.

Next to the codling moth, this small snout beetle is perhaps the most serious of the insects injuring deciduous fruits in the United States, attacking principally plums, peaches, and apples, causing in the aggregate losses of several millions of dollars each year. This species has been under investigation the past two years, especially as an enemy of peaches, the work being conducted at the different field stations and at Washington, but particularly in the Fort Valley section in Georgia, where it is a very important pest of the peach crop. The transfer of the southern station from Georgia, where it had been maintained for two years, to the peach region of the Ozarks, as previously explained, was effected in the spring of 1907, and the work was well begun when the loss of the crop in this section made it necessary to abandon the work for the present. The practical destruction of the peach crop in the orchards available in the vicinity of Washington has also prevented the carrying out of the study of this insect as planned. This project, which it was hoped could be concluded by the close of the growing season of 1907, should be continued another season.

PEACH BORER INVESTIGATIONS.

The life history of the peach borer has now been quite fully investigated in the South Atlantic States (Georgia), the Middle Atlantic States (Maryland and Virginia), and the Northern States (western New York and northwestern Pennsylvania), and the period of emergence and oviposition of the moths determined. Similar studies are now being made in Texas, Arkansas, and southern Ohio, the work in Texas being in cooperation with the entomologist of the Texas Agricultural Experiment Station. These studies have shown important differences in the times of appearance of moths in the respective sections and forcibly illustrate the desirability of studying according to uniform plan the same species in different parts of the country. When similar data shall have been secured for the more central of the middle Western States, it is believed that it will be practicable to indicate quite exactly for all parts of the United States covered by its distribution the best period to apply washes and other remedial measures. Along with the life-history studies of this species has gone the testing of numerous washes and other methods likely to be valuable in protecting trees from its ravages. To be reliable, however, and to determine possible injury from their application to the trees, conclusions as to the efficacy of washes must be based on several years' tests.

SAN JOSE SCALE INVESTIGATIONS.

Work with the San Jose scale has been confined to further tests of various formulas for the lime-sulphur wash, to determine an efficient and economical formula which may properly be recommended for adoption as a standard, as well as many other points connected with its preparation and use. This work was concluded in the fall of 1907 and a formula has been decided upon as best for recommendation, namely, lime 20 pounds, sulphur 15 pounds, water to make 50 gallons, and cooked for one hour. The more important conclusions are included in an article on "Lime-sulphur washes for the San Jose scale," in the Yearbook for 1906, and a more detailed report is now in the course of preparation.

These tests, made in widely separated localities, show that in general a wash properly made and applied is equally effective in all latitudes in the Eastern States and constitutes a cheap and efficient treatment for this pest, which but a few years ago seriously threatened the fruit-growing industry in the East.

Other scalecides have been tried, including the principal proprietary preparations, such as the so-called miscible oils, and some attention has been given to devising washes less troublesome to prepare than is the lime-sulphur spray; but thus far nothing has been found so effective or cheap as the well-made lime-sulphur wash.

The investigation of numerous practical chemical questions concerning the lime-sulphur wash, undertaken in cooperation with the Bureau of Chemistry, has been concluded and reported upon by Mr. J. K. Haywood, in Bulletin No. 101, of the Bureau of Chemistry.

OTHER WORK.

The testing of various arsenicals on peach foliage, alluded to in the report of last year under the head of "Plum Curculio Investigations," indicated the need of further investigations along this line, and a more extensive study has been undertaken in cooperation with the Bureau of Chemistry, tests being made especially of arsenate of lead and the ingredients used in the preparation of the same to determine if possible the conditions under which injury to the fruit and foliage of the peach is likely to occur, and how if possible this may be avoided. Thus far there is no arsenical or effective poison which it is safe to recommend unqualifiedly for spraying peach trees, and such a preparation is greatly to be desired for the control of the plum curculio.

During the past two years a small moth (*Enarmonia prunivora* Walsh) has frequently been bred from apples from various parts of the country, and an investigation of the habits of the larva shows that in many respects these are quite similar to those of the codling moth; it infests the blossom end of the apple, and the second brood especially eats out patches and burrows on the side and in the blossom end of the fruit, greatly disfiguring it. From the observations already made it is certain that the larva of this species and its work have been mostly confused by entomologists and others in the United States with the larva of the codling moth and its work. This insect must therefore be added to the list of those injuring the fruit of the apple in the United States. A careful study of the species is now being made. It appears probable that the measures effective in controlling the codling moth will also keep this species in check.

The demonstration work in canker-worm control mentioned in the last report has been concluded and a report prepared. An investigation of a lepidopterous borer (*Synanthedon pictipes* G. & R.) of the peach and other plants, heretofore mostly confused with the true peach borer, has been concluded and the manuscript prepared for publication.

FIELD-CROP INSECT INVESTIGATIONS.

The work on field-crop insects, under the especial charge* of Prof. F. M. Webster, was continued during the past fiscal year with excellent results. Field work was devoted to the carrying on of the Hessian-fly and joint-worm investigations of the previous year, and owing to a serious outbreak of a grain aphid in the Southwest in the spring of 1907 the investigation of this last insect assumed great importance.

HESSIAN-FLY INVESTIGATIONS.

The wheat-sowing experiments indicated in previous reports were increased during the year in cooperation with the New York, Pennsylvania, and Tennessee experiment stations. These sowings, now numbering over 800, are being carried on at present in eleven States. Exact data are being continually accumulated, showing that it is possible to evade the most serious portion of the fall attack of the fly by seasonably late sowing in the fall. These experimental sowings, which are carried out almost exclusively by the very best farmers, are veritable object lessons, are attracting much attention, and are carefully watched by the farmers throughout the sections where the experiments are conducted.

Work on the Hessian fly in the spring-wheat sections has been continued, and last year's results have been verified. Many new facts have been secured regarding the life of the pest in this new region, and the chief parasite—a *Polygnotus*—has been followed through its life round. The possibility of the practical use of this parasite has been shown in two interesting cases. Early sown plats at Lansing, Mich., and Marion, Pa., were very seriously attacked by the Hessian fly, but when examined carefully at a later date fully 90 per cent of the "flaxseeds" (pupæ) were found to have been stung by *Polygnotus* and to contain its developing larvæ. A field of wheat near Sharpsburg, Md., was found to be infested by the fly, and examination indicated the absence of the parasite. On April 8 a large number of the parasitized "flaxseeds" from Marion, Pa., were brought to Sharpsburg and placed in the field. On July 8 an examination of the Sharpsburg field showed that the parasites had taken hold to such an extent that of the large number of "flaxseeds" taken and brought to the laboratory for investigation not one was found which had not been parasitized. Careful observations of the habits of this parasite in Kentucky, Tennessee, and Alabama have been made, and the observations and collections made in the autumn of 1906 in western Kentucky and northern Alabama have been of material aid.

INVESTIGATIONS OF THE SO-CALLED "GREEN BUG."

The insect known to the farmers in the Southwest as the "green bug" is really an aphid known as *Toxoptera graminum*. It occasion-

ally appears in enormous numbers and causes great damage to small grains. Early in January the insect was reported from eastern central Texas as attacking fall oats. In the area mentioned the temperature was 9° to 12° above the normal. About the same time, as was later shown, it began to breed rather rapidly in fall-sown oats in southern South Carolina, the temperature at the time being from 6° to 9° above the normal. During February the region west of the Mississippi and the Great Lakes was warmer than usual, and during this month much damage seems to have been done in Texas. On March 6 the insect was first reported from Arkansas, and an agent was immediately sent to the field to experiment with measures for destroying the insects in the field, especially over the spots where they seemed to be most abundant, and to determine what could be accomplished in checking the ravages of the pest by the early introduction of its natural enemies into the infested fields. On March 18 several boxes of parasites reached the Arkansas fields from an agent of the Bureau in Texas, but local parasites were already there in great numbers, and further importation of parasites was useless; the "green bugs" were evidently about to be destroyed. The agent then proceeded to various points in Oklahoma, but at Chandler and Guthrie the local parasites were already practically in control. At Kingfisher the parasites were found less plentiful, and parasites were at once introduced in great numbers from Texas and Oklahoma. Proceeding farther, the agent reached Wellington, Kans., on March 30. In the next week thousands of parasites were brought from Oklahoma and liberated. On April 9 it is estimated that more than two and a half millions of parasites were liberated in a single wheat field near Wellington. This was done in order to make a decisive test as to whether it is possible to aid in protecting fields in this manner along the advance line of invasion of the "green bug." The weather was still cold, and it was thought that if the artificial introduction of parasites would, with the return of warmer weather, hasten the control of the Toxoptera, the introduction of a large number would clearly demonstrate this fact; and if such an introduction on a large scale proved favorable it would show a reasonable ground for a more general introduction of parasites in lesser numbers. The weather during the whole of April was generally cold, with an occasional storm that is known to have killed many of the parasites, and though there were brief periods of warm weather during which the parasites would increase rapidly, the Toxoptera was not overcome in southern Kansas until about the middle of May. The weather conditions were almost universally unfavorable to the parasite and therefore favorable to the development of the "green bug." Two agents stationed near Wellington and in northern Oklahoma were constantly watching a wide range of country, and the results indicated that the local parasites developed in other places, aside from the experimental field near Wellington, about as rapidly as in the field where the two and a half millions were liberated. No benefit in this field was indicated above other fields, near or remote, where no artificial introductions were made. Minor introductions were made at McPherson and at other points, and in no case was there a field of the hundreds examined in southern Kansas where the number of parasites natively present did not outnumber by many

thousands or hundreds of thousands those liberated artificially at a time when weather conditions had become such that the liberations could have had any benefit. When weather conditions became favorable, parasites were abundant in equal numbers in all fields. The weather is the important influence, and without favorable weather artificial introduction of parasites does little good in the case of this insect.

On May 13 Professor Webster visited the field and conducted a further experiment in this direction, with a view to hastening the work of the parasites during favorable weather by large introductions. Two fields of oats near Manhattan, each containing 4 acres, were selected. These fields were sufficiently widely separated. One of them was used as a check, and into the other were introduced very great numbers of parasites sent from Wellington. Careful count showed that in these fields the percentage of native parasitism at the beginning of the experiment was from 3 to 7. On May 18 many hundreds of thousands of parasites were liberated in one of these fields. On May 23 in this field the parasitism had increased only about 2 per cent, whereas in the check field, in which no parasites had been liberated, it had increased 12 per cent. On May 27 the percentage of parasitism in the field into which the parasites were introduced had reached 27, while in the check field it was 32. It was thus clearly demonstrated that, even under weather conditions favorable for the development of the parasites, an introduction to the extent of millions carried out under field conditions does not indicate enough efficiency to afford any encouragement for the use of this measure in the protection of the grain fields in case of future attack. It seems that with all the artificial introductions of this parasite that were made in the spring in grain fields of Kansas and the adjacent States and Territories there is no probability that a single bushel of grain was saved by such introduction. Similar substantiating experiments were conducted in North Carolina and Virginia. Careful study was made of the life history of the most important of these parasites, a minute braconid of the genus *Lysiphlebus*.

Extensive experiments were made with mechanical artificial remedies. Owing to the fact that the insect usually makes its appearance numerous in spots and spreads rapidly from these places, it becomes desirable to know some method of quickly destroying it in the spots first attacked, even at the sacrifice of that portion of the crop in order to protect the rest of the fields. It was shown that these spots can be treated successfully by plowing under and then harrowing and rolling the surface of the ground, by spreading straw over them and burning, or by treating with a 10 per cent solution of kerosene emulsion. In the southernmost regions infested by this pest, however, the greatest difficulty does not seem to arise from these isolated spots, which seem to extend outward from day to day, but from the fact that, after their food supply has become either largely destroyed or the grain is too old and tough for them to feed upon, immense swarms of winged adults are produced, and these drift in general northward with the advance of the season and infest the grain fields of entire sections of the country much earlier and more completely than would be possible from the scanty stock natively present. This habit is also seen in the behavior of the pest

in its original home, in Europe. It may therefore prove that the country north of the Red River may be more or less protected if the pest can be early overcome in northern Texas.

JOINT-WORMS AND OTHER GRAIN INSECTS.

Some work has been done with an important enemy of the wheat joint-worm, and investigations of the timothy joint-worm have been continued. It is shown that the damage to the seed of timothy by the action of this insect is greater than the damage to the hay crop. Rotation of crops seems to be the most practical preventive measure with both of these insects.

Further investigations have been made on the seed-corn ground-beetle and the corn root-aphis and a number of other insects belonging to this group.

WORK ON INSECTS INJURIOUS TO VEGETABLE CROPS.

The work on insects injurious to vegetable crops, under the charge of Dr. F. H. Chittenden, has been somewhat developed during the past year. Especial attention has been given to insects affecting this class of crops in the Southern States and to the insect enemies of the sugar beet in the West.

INVESTIGATIONS IN THE SOUTHERN STATES.

A special agent was sent to southern Texas in March to establish headquarters in Corpus Christi, where work was begun upon such prominent southern pests as the bollworm in its occurrence upon tomato and other truck crops. The onion thrips was the subject of special study in its occurrence on onions. Cooperative demonstration work against the melon aphis was carried on as in the previous two years with the Texas Agricultural Experiment Station, and studies were made of three species of leaf-beetles which affect cucurbitaceous and other truck crops.

A similar line of investigations was conducted by an agent in Florida, who, however, did not begin work until May, and whose investigations must be considered simply as preliminary. The species which have so far formed the subject of special investigations in this region are the pickle worm, imported cabbage webworm, and the melon aphis. A study has been begun of the natural enemies of the melon aphis, looking to a possible exchange with the Texas Agricultural Experiment Station, provided insect enemies are found in one State that do not occur in the other.

Study was also begun of the cabbage looper, the grass worm in its occurrence on sweet corn, a destructive cutworm, plant-bugs, flea-beetles, and certain other species.

ENEMIES TO THE SUGAR BEET.

The scope of the investigation of the insect enemies of the sugar beet, which have been under continuous observation for a number of years, was augmented by the employment of a special field agent in cooperation with the Utah State Agricultural Experiment Station to study the principal pests found in Utah, Idaho, and Colorado. A destructive leaf-hopper (*Eutettix tenella*), known in that region as the white fly or blight and as the supposed author of "curly leaf"

from the effect of its injuries to beets, has received special attention, and an extensive account of its life history and habits has been prepared and is available for publication. The publication when completed will contain also short notices of related species occurring in the same regions, together with suggestions for the control of leaf-hoppers.

In the autumn of 1906 a temporary field agent was employed to investigate the local conditions of sugar-beet insects of southern California. Especial attention was given to the beet aphid, flea-beetles, and the leaf-beetles.

OTHER INVESTIGATIONS.

A number of other important species occurring upon truck crops have been under observation, and a bulletin has been published on the asparagus miner and the asparagus beetles.

WHITE FLY INVESTIGATIONS.

For some years there has been a desire on the part of important interests in Florida to have the Department undertake a new and thorough investigation of the injury by the white fly to citrus fruits in that peninsula. The white fly has for many years been one of the greatest obstacles to the success of the citrus industry in Florida, and has been studied by the Bureau of Plant Industry from the standpoint of the sooty fungus which follows it, and by this Bureau from the life history side and means of control. A preliminary survey of the territory was made in 1905, but no appropriation for extended work was available until the fiscal year beginning July 1, 1906, when Congress specifically designated \$5,000 for this investigation. This work has been under the direction of Mr. C. L. Marlatt, Assistant Chief of the Bureau, with Mr. A. W. Morrill, special agent, in field charge, with headquarters at Orlando, Fla., assisted at various times by men temporarily transferred from other investigations, and by a special appointee, Mr. Stephen Strong, for two months as fumigation expert from California.

The white fly is an important pest throughout the Gulf region, and this year has been found fairly well established about Marysville, in California. This California outbreak was entirely unexpected, as the climate of the Pacific orange districts is distinctly unfavorable to this pest. The white fly requires a considerable rainfall or humidity, and there is reason to hope, therefore, that the California outbreak is a temporary one, induced largely by a season of exceptional rainfall and moisture in the region designated. As a matter of fact, radical measures instituted by the State Horticultural Commission have apparently eradicated the pest.

The work done during the year with the white fly in Florida includes (1) life history studies; (2) natural control, i. e., by parasitic insects or fungous diseases; and (3) control by the use of insecticides or by "gassing."

While the life history of the white fly has already been pretty carefully worked out in its main details in the earlier work done with this insect, still much information of distinct value is resulting from the present more thorough and detailed study. The greater part of the year covered in this report was one of unusual drought in Florida,

and it has had the general effect of greatly reducing the abundance of the white fly and is confirmatory of the fact, stated above, of the dependence of this pest on a considerable amount of moisture. With the return of normal conditions, however, the pest is now rapidly increasing to its usual status.

One of the most important factors for the natural control of an insect like the white fly is parasitic enemies; but unfortunately the white fly in Florida seems to be devoid of true parasites. Efforts are being made, however, to obtain parasites of other species of the same genus (*Aleyrodes*) to which the white fly belongs, and to introduce these into Florida in the hope that some of these may eventually become important means of control. There are many species of *Aleyrodes*, and some of these in different parts of this country and in foreign countries seem to be controlled by parasites. Several native predaceous insects have been found to prey upon various stages of the white fly, but thus far they produce no important check.

The most useful natural-control agencies are parasitic fungi, which have, especially in the southern range of the white fly, been often of very great service in checking it and which sometimes almost exterminate it for a period. In Manatee County, where the two important species of fungous enemies have been longest established, they result on an average of one year in three in checking the white fly sufficiently to free the trees and fruit from the sooty mold which follows white fly attack, and all the time reduce the amount of injury very much. The investigation of these fungi, and particularly the determination of means of experimentally increasing their range and efficiency, is one of the most important of the problems connected with the white fly work. The benefit from them is especially noticeable in regions with a high degree of humidity, but from the present examination of the subject it does not seem likely that they can ever be made equally effective in the drier citrus regions in Florida.

A good deal of insecticide work has been done in Florida in former years against the white fly, principally, however, with liquid sprays, such as resin wash and kerosene emulsion. No such work, however, against the white fly is effective unless it is general, as the insect flies readily and is carried by winds from one orchard to another, so that it spreads much more quickly than is the case with scale insects. While spraying has been practiced to a great extent in Florida, it has been irregular and often fails to give satisfactory results. A thorough investigation of the use of liquid sprays is in progress.

The use of hydrocyanic-acid gas has not been adopted in Florida to any extent, but the necessity of thorough work on trees would seem to indicate the great desirability of this method of control of the white fly. To take advantage of the large amount of practical experience which has been gained during many years in California in gassing citrus trees, the services of Mr. Stephen Strong, one of the horticultural commissioners of Los Angeles County, were secured for two months last winter to introduce and superintend the hydrocyanic-acid gas fumigation in Florida. The results already reached from these experiments indicate that under favorable conditions— isolation from other infested groves or where concerted action can be had—fumigation is more economical than spraying, and much more certain in its results than reliance on natural enemies.

There has been no official publication during the year giving the results of the investigation, but articles by Mr. Morrill covering special features of the work have been published in the agricultural press of Florida, and a paper was presented before the Southern States Association of Commissioners of Agriculture and also before the Florida State Horticultural Society.

INVESTIGATIONS OF INSECTS IN THEIR DIRECT RELATION TO THE HEALTH OF MAN AND DOMESTIC ANIMALS.

MOSQUITOES AND HOUSE FLIES.

Work has been continued on the Monograph of the Mosquitoes of North and Central America and the West Indies, and a skilled agent has been sent to Panama, in cooperation with the Isthmian Canal Commission, to study the mosquitoes of the Canal Zone, with especial reference to the geographic distribution and breeding conditions of the species that carry disease.

No further work on the house fly has been done, but extensive correspondence has been carried on with individuals and with boards of health. A revised edition of Circular No. 71 of the Bureau has been published and widely distributed.

WORK ON THE TEXAS CATTLE TICK.

The importance of the extermination of the cattle tick has recently been brought prominently to public attention. Absolute extermination seems feasible. The work on the life history and habits of the tick, on which means of eradication or control must be based, falls naturally within the province of the Bureau of Entomology, while the eradication or control work itself is carried on by the Bureau of Animal Industry. Some good work on life history and habits has been done by a few of the State officers of the South, but this work has been far from commensurate with the magnitude of the problem. As indicated in the last annual report, a beginning was made in the study of the tick at the urgent request of many experiment-station officers and cattle raisers of the South. This work was done in connection with the cotton boll weevil investigation, and necessarily could not be of an extensive character. Nevertheless the experiments and observations made during the year revealed many points of practical importance. The results are soon to be published in a bulletin by the Bureau. The work under way is designed to show the variations in the development of the tick on the hosts and the duration of the period passed on the ground. The interrelationship between these periods is the most important matter that must be taken into consideration in formulating plans for control. The principal work under the Bureau is being done at Dallas and Victoria, Tex. The longevity of seed ticks is being tested and the probable duration of the egg stage under various conditions. Cooperation has been obtained with experiment stations, and notably with the Tennessee station.

In connection with the study of the cattle tick, it has been possible to make observations on a number of other species of ticks that are now of considerable importance as animal parasites. Some of these

may assume much greater importance if they are found to be concerned in the transmission of disease. In this work several species not known previously to occur in the United States have been taken by agents of the Bureau, and notes have been made on their life history and means of control. Other species known to occur in the United States, but which have not been carefully studied, are receiving attention.

WORK ON SCALE INSECTS.

The principal scale pests are in evidence every year, and even the San Jose scale has become so thoroughly well known and understood that its steady extension causes no special excitement. Practical control by remedies is becoming more efficient every year. Some special work with insecticides against it has been referred to in another place. The requests for information on this and other orchard scale pests are a steady and considerable factor in the correspondence of the Bureau. Among the scale pests which are not strictly orchard or small-fruit species several have been especially complained of during the year. For example, the magnolias in the Gulf States seem to have been badly infested with a *Lecanium* soft scale, *Toumeyella turgida* Ckll. Another species of this genus, *Toumeyella pini* King, appeared in injurious numbers on young seedling pines in several eastern nurseries. The soft scale of the tulip tree is reported to be damaging tulip and magnolia trees in various localities in the Eastern States. A common West Indian scale pest, *Asterolecanium pustulans* Ckll., is gaining a foothold in the vicinity of Miami, Fla., on oleander, fig, mango, and other plants. *Pulvinaria pyriformis* Ckll., also a West Indian scale affecting guava, cinnamon, and Persea, has been found in Florida on cinnamon trees, this being the first record of the species for the United States. The cottony maple scale (*Pulvinaria innumerabilis*), referred to in a former report as having been so generally prevalent during the last three years, seems in great measure to be under the control of its natural enemies, and very few complaints have been received this year of damage by this insect. This native species, as pointed out in earlier reports, is one that seems to have a periodic habit produced by the action of natural enemies. Just now, fortunately, we are apparently entering into a period when such natural control is efficient.

EXPERIMENTAL WORK WITH INSECTICIDES.

With the broadening of the work of the Bureau and its separation into definite investigations, the experimental work with insecticides becomes naturally more or less divided and assigned to the different fields of entomological research.

The profit from insecticide applications is marked in the case of the insect enemies of the deciduous orchard fruits and of small fruits, and the following experimental work in this field is under way or has been completed: (1) A careful testing of various formulas of lime-sulphur washes for the San Jose scale, carried out in three distinct latitudes and extending over a period of two years. In connection with this work several other substances of possible value against the San Jose scale have been tested, including the

miscible oils. (2) A thorough testing of the effect of various arsenicals, with and without lime, on the foliage of peach, was begun in the spring of 1906, and is being continued this year. (3) In cooperation with the Bureau of Chemistry, an examination is being made of as many brands as possible of arsenate of lead collected from various sources in the open market, and also an investigation of the method of preparation and proportions of the ingredients. (4) In connection with the investigation of the codling moth, the peach borer, and other fruit insects, washes commonly employed are being tested, together with various new combinations.

As already stated, the white-fly investigation of the Bureau in Florida has led to an examination of the possibilities of introducing into Florida the gassing method so long the standard means of controlling scale insects on citrus fruits in California, and some very careful preliminary experiments have been made. The results are very favorable, and the outlook now is that gassing can be made effective against the white fly. This work, however, has only been begun, and the investigation will be continued the coming fall and winter. The work in Florida will be conducted in cooperation with and as a check on the careful investigation of the whole question of gassing citrus trees which is to be instituted with the fiscal year beginning July 1, 1907, in southern California.

The effect of gassing on the eggs of such scale insects and aphides as hibernate in the egg stage, or pass a considerable resting period in the egg stage, is a subject of the greatest practical importance, and particularly in the fumigation of nursery stock and of new or other plants imported from foreign countries. Hydrocyanic-acid gas has been demonstrated to be the most effective and sure means of destroying scale and other insects on nursery stock or other shipping plant material; but unless it also kills the eggs under the conditions noted the protection is necessarily faulty. This whole subject has been taken up for careful investigation, and some preliminary experimental work has been done with the scurfy scale and the oyster-shell scale, and the apple aphid, all of which winter in the egg stage. Results indicating the requirements of fumigation for this purpose will probably be reached by the end of the next fiscal year.

In connection with the other special lines of work of the Bureau, more or less insecticide investigation has been carried on with stored grain pests, insects affecting cereals, and those affecting shade trees and ornamental plants.

The examination of new remedies for insect pests, and the reports thereon, which are presented to this office from all parts of the United States and from foreign countries with almost every mail, is a part of the regular routine. The active work being done with the boll weevil, the gipsy moth, and the San Jose scale evokes innumerable suggestions, very generally, however, from people who have had no acquaintance with the underlying needs, and therefore in ninety-nine cases out of a hundred these suggestions are either valueless or a repetition of methods already in common use.

INVESTIGATIONS OF INSECTS AFFECTING TOBACCO.

In the bill making appropriations for the Department for the fiscal year ending June 30, 1908, a clause was inserted providing for investi-

gations of insects injurious to tobacco in the dark-tobacco belt of Tennessee and Kentucky. Unwilling to wait until the beginning of the fiscal year before commencing this apparently important investigation, the Bureau sent an expert assistant to the region late in May to make a preliminary examination of the field. He visited Springfield, Tenn., and made examinations along the road from Springfield to Clarksville, Tenn., at Hopkinsville, Ky., and along the road from Guthrie, Ky., to Russellville, Ky.

Some studies were made of the tobacco flea-beetle, which seems to have been especially injurious this year, of cutworms, of aphides, and of a few other species. Experimental plats in Springfield and Clarksville, Tenn., were arranged for, and cooperation with the Tennessee and Kentucky experiment stations was also arranged. A permanent special agent was placed in the region in question at the beginning of the present fiscal year.

INSPECTION WORK.

The Department of Agriculture, through the activities of the Bureau of Plant Industry, has become perhaps the largest importing agency of new stock in the United States. Much of this material comes from quarters of the world which have never been explored entomologically and from which there has been naturally very little commerce in plant material, and therefore all such material is very apt to harbor insect pests new to this country. The worst insect pests of America are those of foreign origin, as illustrated by the San Jose scale, the codling moth, and the black scale in California. To prevent, therefore, the introduction of new important pests, all the plant material imported by the Department of Agriculture is given most rigid inspection by Mr. J. G. Sanders, who has been put in charge of this work. During the year, 916 lots of imported plants were inspected for dangerous insects, the largest of these containing over 5,000 plants. Many of these lots of plants and seeds have been fumigated, and whenever fumigation was impracticable or for any reason inefficient the shipments found infested have been destroyed.

All plants imported from foreign lands or home-grown sent out by the Department of Agriculture are inspected, fumigated, and cleaned, if necessary, before a certificate is granted. Since July 1, 1906, 581 certificates have been issued for the shipment of plants from the greenhouses of this Department.

In connection with this inspection it was very interesting to find the San Jose scale (*Aspidiotus perniciosus* Comst.) very scatteringly present on twigs of pear and apple which had been shipped to the Department from the interior of northern China, notably from Manchuria, by Mr. Frank Meyer, agricultural explorer. The finding of this scale insect scatteringly on these plants is an important confirmation of the results of the exploration by Mr. Marlatt and the determination by him of this very region as the original home of this great pest. The scattering nature also of the infestation would indicate the control locally of the scale by native parasites and predaceous enemies or diseases, and makes it desirable at some future time to have this whole region carefully explored for parasites or other means of natural control of the San Jose scale.

On twigs of pear from Manchuria was found a peculiar new species of *Parlatoria* which, from the known habits of the group of scale insects to which it belongs, might easily prove to be as bad a pest as the San Jose scale. To preclude any possibility of the introduction of this dangerous scale, all the infested scions were burned, and all other woody material strongly fumigated three times.

WORK IN BEE CULTURE.

During the past fiscal year the work in apiculture has been reorganized, Dr. E. F. Phillips having been placed in charge, and the facilities for the work materially increased.

The chief problem taken up was the investigation of the brood diseases of bees. The principal hindrance to the greatest possible advance of apiculture in this and other countries is the fact that the bee is subject to several diseases, which are widely distributed, and which constitute often a prohibition and always a hindrance to progress. It therefore has seemed best to devote considerable time to this investigation.

At the very beginning of the year the apicultural expert took an extended trip through California, Wisconsin, and Michigan for the purpose of studying the spread of the disease and the methods used by various practical men in its treatment. It was quite evident that there was need for a short publication outlining the symptoms of the various diseases and the treatment, and consequently Circular No. 79, *The Brood Diseases of Bees*, was prepared and has been widely distributed.

Dr. G. F. White, then of the Bureau of Animal Industry, offered for publication a paper entitled "The bacteria of the apiary, with special reference to bee diseases," which had been prepared by him as a thesis at Cornell University. This paper deals with bacteriological work on the brood diseases of bees, and also contains an account of the normal bacterial flora of the apiary. It was published as Technical Series No. 14.

The work of Doctor White, as well as that of other investigators, made it desirable to take up for consideration the names to be used for the various diseases. Much confusion existed and still exists in some quarters. After consulting by correspondence with some of the leading bee keepers of the United States, it was finally decided to adopt the name American foul brood for the prevalent brood disease of the United States which had hitherto been called simply foul brood and the name European foul brood for the disease known as black brood. These names have been adopted by the bee journals of the United States.

To bring about greater cooperation among the official inspectors of apiaries as well as to spread knowledge concerning the brood diseases of bees, a meeting of inspectors of apiaries was held at San Antonio, Tex., November 12, 1906, under the auspices of this Bureau. This meeting was well attended and attracted considerable attention among persons interested in bee-disease work. The proceedings of this meeting have just been issued as Bulletin No. 70 of this Bureau.

At the San Antonio meeting the Bureau of Entomology was requested to make a study of the workings of the various laws now in force for the control of bee diseases. To aid in this work a list of questions was sent out to all the official inspectors asking them

about the results obtained by them under various provisions of the law; information has also been gathered from all other possible sources. This material is now being gathered together.

Following the San Antonio meeting a similar meeting of the California inspectors of apiaries was held, December 8, 1906, under the auspices of this Bureau.

Whenever possible the apicultural expert and the special agent in California have gone out with the inspectors on their trips. Some new points may always be gleaned from the better inspectors and these are in turn given to those less able to control the situation. While this has been done only incidentally, it has seemingly resulted in considerable good.

Several investigators in Europe have been at work on bee diseases, but because of inadequate descriptions of the diseases and of the organisms found in them great confusion exists. It is essential that the organisms causing bee diseases in this country be known. To provide for this part of the work a small bacteriological laboratory was installed in the spring. The first problem to be taken up was the devising of media suitable for the cultivation of microorganisms which are present in diseased material; the usual laboratory media are not entirely satisfactory and certain of the organisms found fail to grow on them. A medium of filtered bee larvæ has been made on which *Bacillus larvæ*, found in American foul brood, grows freely. This bacillus does not grow on media made of beef. It was also necessary to devise methods for making test inoculations, and in this respect also the results are proving satisfactory. It has been determined that *Bacillus larvæ* is the cause of American foul brood. For the first time this disease has been produced by feeding pure cultures. The details of the media and inoculation methods, as well as the results of the preliminary inoculation experiments, have been published as Circular No. 94 of the Bureau. In connection with this work a large number of samples of diseased brood have been received, and information has been sent out as to the kind of disease present.

The work on "paralysis," a disease of adult bees, has been continued in California. To test the theory that this disease is caused by poor strains of bees, some apiaries in the diseased district have been stocked with queens of good strains. It is too early to tell what result may be expected. So far no evidence of the influence of a microorganism has been found.

The distribution of breeding material of the various less known races of bees was carried on during the summer of 1906, with the result that these races are now offered for sale by various competent breeders. This method of distribution is much more satisfactory than was the promiscuous distribution of former years, which was greatly misunderstood by bee keepers. For the present this distribution on the part of the Bureau has been discontinued.

The work on honey-producing plants has been continued at the substation in California as far as time would allow. Several valuable honey-producing plants have been sent to various parts of California to be tested under the direct supervision of the special agent. Arrangements have also been made to send some of the principal honey-producing plants of the West to the Hawaiian Islands for testing.

To test the comparative value of the various races of bees in fertilizing red clover, a series of cages has been erected to exclude all other bees. This experiment is of interest not only in regard to clover fertilization but also in studying various things connected with the habits of bees.

A list of the honey-producing plants of the United States has been begun which will prove very valuable in future investigations along this line.

The enactment of the food and drugs act, June 30, 1906, proved of great interest to bee keepers and promises to be of great assistance to them in preventing, or at least limiting, the amount of adulteration of extracted honey. In the Hawaiian Islands there was last year produced about 400 tons of "honey-dew honey." Previous to January 1, 1907, this product was sold as honey and with no qualifying clause. During the present calendar year this office had considerable work to do in regard to the method of selling this product in the United States markets, and finally a satisfactory arrangement was made whereby it is to be sold as "honey-dew honey." Several other important problems connected with bee keeping in the Hawaiian Islands have been considered, and more work will be done during the fiscal year 1907-8.

To further the work of detecting the adulteration of honeys, a large number of samples of pure honey from known sources has been collected by this Bureau and has been analyzed by the Bureau of Chemistry of the Department. The results of this work will be published shortly by the Bureau of Chemistry.

In order to find out the status of bee keeping in the New England States the Bureau is engaged in a detailed study of bee keeping in Massachusetts. Every bee keeper whose name can be obtained is asked to answer certain questions regarding the industry in his own town and to give certain information regarding his own apiary. The percentage of replies is extraordinarily large. This not only enables the Bureau to get detailed information which could otherwise be obtained only at great expense, but it has aroused considerable interest in the industry and promises to result in considerable good by putting the publications of the Bureau into the hands of the proper persons. In advancing bee keeping as an industry it is quite desirable to make the persons now engaged in the keeping of bees better bee keepers rather than to induce a greater number to engage in apiculture.

That bee keeping could be carried on to a much greater extent in many sections of the country is quite obvious; it is also a well-known fact that the United States does not now produce enough honey to supply its own market. It is very desirable, therefore, that the industry be advanced by the introduction of the latest and best methods. The work which the Bureau is now doing in Massachusetts is demonstrating the discrepancy between apiculture as it now is and as it may be, and further, it should show how much good may be accomplished by communicating directly with interested persons to bring to their attention desirable information.

This work is being done in Massachusetts because of the fact that it was possible for the Bureau to get as a collaborator in this work Mr. Burton N. Gates, who has been for some time interested in the industry in that State. If the future results are what they now

promise to be, an effort will probably be made to extend the work to other States. At any rate the work will demonstrate the possibilities of the method.

A detailed study of bee keeping in the Hawaiian Islands has recently been begun by Mr. D. L. Van Dine, entomologist for the Hawaii Experiment Station. This work was begun by Mr. Van Dine as an official of his station, but it is to be continued under this office. There are certain things connected with the industry on these islands which make the work of interest not merely to the bee keepers of Hawaii, but equally to bee keepers of the mainland, and it is desirable that this be done under this Bureau.

WORK IN SILK CULTURE.

No changes have been made in the methods that have been followed for some years in the effort to encourage the production of silk in the United States. The interest during the past fiscal year, judging from correspondence, has fallen off. It has been retained to a considerable extent in New York, Pennsylvania, California, Illinois, Missouri, and Texas, but in the other States the interest in this line of work has lessened. It is probable that this falling off in correspondence is due to two factors. The first is one that was pointed out last year—the lack of newspaper and syndicate articles which tend largely to advertise silk culture. Heretofore there has been an abundance of such articles spread from one end of the country to the other, but this year not a single syndicate article appears to have been published. The second factor is lack of interest, furthered by the prosperous condition of the country, which makes larger returns from other lines of work a natural consequence. The returns from silk culture are necessarily small, and it has been the aim of the Department to interest mainly individuals otherwise nonproductive, or those who might make it a small side issue to other farming operations. Should there come a check to the country's prosperity, it is probable that interest in silk culture would immediately revive.

PURCHASES OF SILKWORM EGGS AND THEIR DISTRIBUTION.

Eighty-five ounces of bacologically examined eggs were imported from Italy for distribution to applicants in the spring. The shippers carefully marked the package to be delivered to the Government dispatch agent in New York, and placed it in the hands of the steamship agents to be kept in cold storage en route. Instead of following directions, the steamship agents delivered the package to their own house, and after a week's delay in warm weather forwarded it in bond to the Georgetown custom-house, where there was another week's delay in the delivery of the eggs to the Department. They were found, on examination, to be practically ruined, and the matter was placed in the hands of the Department's law officers in order to recover damages, if possible, from the steamship company. A duplicate order was cabled to Europe immediately, and on February 2 the second shipment arrived by the proper channels and was found to be in excellent condition. There were 13 pure and 8 crossed races, making rather a close resemblance to the importations of previous years. They were placed in cold storage and were drawn in small

quantity from time to time as required. One ounce of eggs of four different varieties was purchased from a French dealer, and 1 ounce of Turkish eggs raised at the American Orphanage at Harput, Turkey, was presented by the United States consul at that place. These special lots of eggs were placed in the hands of experienced rearers who have not yet reported. All of the eggs received, with the exception of the first shipment, seemed remarkably healthy and absolutely no complaints have been sent in. There seems to be no pébrine disease existing among the silkworms in the United States at the present time. The previous year it existed at one locality in Cuba.

There seems to have been a certain amount of home production of eggs in spite of the recommendations of the Department that no eggs should be used except those guaranteed free from disease.

The total sendings of silkworm eggs from the Department this year number 343, as against 413 last year. The geographic distribution of the sendings follows rather closely the lines indicated in the discussion of the silk-culture correspondence, California, Kentucky, the District of Columbia, Georgia, Illinois, Indiana, Kansas, Massachusetts, Maryland, Michigan, Missouri, Nebraska, New Jersey, New York, Ohio, Pennsylvania, and Utah receiving the largest numbers. About 74 ounces in all were thus distributed before the close of the fiscal year.

DISTRIBUTION OF MULBERRY STOCK.

As in the previous year, seedlings of the best white mulberry from Lombardy and Sicily were distributed to all applicants during the late fall and spring, none being sent out during freezing weather; 10,850 in all were sent out. This is a falling off from the sendings of last year, but to a certain extent some silkworm raisers have received all the seedlings they require or have room for planting. The shipments have been made mainly in lots of from 25 to 50, with occasionally one of a hundred or of several hundreds. Two thousand seedlings were sent to Hawaii. Two kilograms of a good variety of seed were purchased from Milan as a basis for next season's supply of seedlings. These seeds were turned over to the Department's farm at Arlington for planting, in the same manner as previous lots, and are reported to have shown a good germination test.

From all over the country reports of injuries to the mulberry foliage by cold weather have been received. In most cases the foliage was starting well and was then cut off by frost. As a consequence many persons have lost their silkworms through lack of food, and this has had a serious effect upon the quantity and quality of the cocoons offered for sale to the Department, as will be shown later.

SALE OF REELED SILK.

During the year several ineffectual efforts were made to sell the raw silk which had been produced by the Department reels and which has been accumulating for some time. In June a bargain was made with Belding Brothers & Co., and the total amount on hand, 253 pounds, was sold at \$4 a pound, bringing a return of \$1.012. This amount was immediately deposited with the Treasury

Department in compliance with the regulations. The price of raw silk has been steadily advancing for six months past, and by June of the present year ranged from \$3 to \$5 for Italian silks, Japanese silks, however, selling for something over \$6. The bulk of the product at the Department was Italian silk, the proportion of Japanese silk being very small. It is therefore thought that \$4 a pound represents a very fair value, considering that the reeling was done by American women of very short experience. All attempts to dispose of the waste products (frisons, pierced and double cocoons, and so on), have been ineffectual; there seems to be little demand for this material.

COCOONS PURCHASED.

American-raised cocoons have been purchased during the past year whenever offered, at rates of \$1.15, \$1.05, and 90 cents per dry pound for first, second, and third class cocoons. The Department has continued to assume the expense of transportation, providing for the purpose Government franks sent on application. While the standard of quality has been fully maintained, there has been a considerable falling off in the quantity of cocoons offered for sale, and it has amounted to hardly a third of that offered last year. This loss is to be attributed to some extent to the heavy spring frosts, which destroyed the mulberry foliage, and also to the fact that the eggs sent out a year ago were slightly below standard; but it was evidently due in part to a falling off in interest among producers for reasons already stated. Under ordinary conditions, the cocoons of the new crop begin to come in in straggling lots in May, and during the month of June they are usually being freely offered. During June of 1907, however, the end of the month showed the cocoons coming in but slowly, and the bulk of the buying ran over into the present fiscal year.

REELING OPERATIONS.

Reeling has been conducted as in previous years, only one of the two 4-basin Berthaud reels being operated. There is no available space for setting up the second machine, and no necessity for its use even if there were enough available cocoons to make its operation desirable. At the end of the last fiscal year 3 operators were actively employed in reeling. Their number was increased in July to 5, with the addition of an apprentice serving without pay. The 5 were employed until the end of December, when the reels were closed down for the year.

Four threads have been used exclusively, except in rare instances, when 5 and 6 were employed.

MISCELLANEOUS INVESTIGATIONS, THE EXHIBIT AT THE JAMESTOWN EXPOSITION, AND OTHER WORK.

As in previous years, several additional investigations have been entered into during the year, and some of the principal ones may be mentioned briefly here.

The investigations of the insects affecting stored products have practically been completed. A few questions of a nature not discussed in Farmers' Bulletin No. 45 are occasionally asked in corre-

spondence, necessitating continued investigations of a minor character.

A special agent in Florida has investigated some of the principal insect enemies of the pecan in that State, especially the budworms, which are credited as being the most destructive of the pecan insects in this country. Some elaborate work on the insects affecting acorns of the different species of oak has been begun looking toward a somewhat complete consideration of the subject. Investigation of insects injurious to shade trees has been continued, as in the previous year, and the increasing importance of some species, such as the imported willow curculio, will necessitate further observations with a view to discovering better methods of control than have hitherto been devised and employed. This insect is now very generally distributed throughout the Northern States, from Maine through New England, New York, Pennsylvania, and Ohio to Wisconsin, Minnesota, and North Dakota. It is a pest on poplar and willow, and is especially troublesome to nursery stock.

Much study has been given during the year to the important parasites of scale insects, and a technical bulletin has been published describing a number of forms new to science that either have been imported into the United States or have been sent here for study by the entomologists of foreign countries.

The exhibit of the Bureau of Entomology at the Jamestown Tercentennial Exposition occupied the time of one of the trained assistants of the Bureau for a portion of the year. It was arranged in sections so as to facilitate the location and study of any particular pest in the collection. The following subdivisions comprised the main part of the exhibit: Insects injurious to southern field crops; Insects injurious to fruits; Various insect pests; Parasites of domestic animals; and Household insects. A prominent place was given to the enlarged models of the malaria mosquito and the life history of the protozoan parasite carried by it. Large models of the yellow-fever mosquito and the salt-marsh mosquito were also exhibited, and the large models of the codling moth, the San Jose scale in all stages, the chinch bug, the Hessian fly, the house fly, and others attracted much attention from the visitors to the building.

The correspondence of the Bureau was increased over the previous year, necessitating a still further enlargement of the clerical force. The routine work in the insectary has also increased, and biological studies have been made of a large number of species not hitherto investigated. The work of determining the specimens for the entomologists of State experiment stations and other workers has also increased over the previous year. Many thousands of specimens have been received from these workers, and a considerable part of the time of a number of expert assistants was taken up in this way. This work is important and is a proper function of the Bureau, although it is barren of immediate practical results.

PROPOSED WORK FOR THE FISCAL YEAR 1908.

Work for the fiscal year is now well under way, and naturally, for the greater part, it consists of a continuation of the lines of investigation just indicated. Several new lines of work, however, have been added during the present fiscal year at the direction of

Congress. The first of these is an investigation of the insects injuring tobacco in the dark-tobacco sections of Tennessee and Kentucky, and some reference to this work has already been made in the body of this report. The second new investigation consists in a study of the depredations of the grape root-worm in the Erie grape belt of Pennsylvania with a view to carrying out demonstration work in its control. Provision was made to begin this work in the spring of 1907 on account of the necessity for an early start well before the beginning of the new fiscal year. Series of experiments and demonstrations are now in progress, including tests of sprays, timely cultivations, and the renovation of vineyards already seriously injured by the grape root-worm. Together with this work other important grape pests are being investigated, such as the grape berry moth, the grape leaf-hoppers, rose chafer, and others. This work is limited practically to the Erie grape belt and is carried out in connection with other investigations of deciduous fruit pests at the field station at North East, Pa.

Another new line of work consists in an investigation of the depredations of deciduous-fruit pests in California. The large fruit interests in that State and the recent attack of the pear thrips in the Santa Clara Valley led to a provision by Congress for the establishment of a field station in that State for this purpose, beginning with the fiscal year 1908. Two well-trained men, familiar with California conditions, have been assigned to the work, and attention will be at once given to the more important insect pests, such as the pear thrips, codling moth, California peach borer, grape *Phylloxera*, and others.

Attention was called in the last report to the desirability of establishing a field station on the Pacific coast for the investigation of insects injurious to grains. With the added funds appropriated by Congress this has become possible the present fiscal year, and an expert assistant has been placed in northern California to study all cereal and forage crop insects of the far West. Had this station been established during the last fiscal year, it would have been possible, by the transfer of parasites of the Hessian fly from the East, to bring about results of practical value, since the damage done by this insect in northern California during the summer of 1906 was severe.

Another new project taken up with the beginning of the fiscal year 1908, at the especial request of several of the horticultural commissioners of California and at the instance of Members of Congress representing the principal citrus districts, is the investigation of hydrocyanic-acid gas fumigation in southern California. The fumigation of citrus trees with this gas to control scale insects has been in California the standard means of control for years. The methods now followed are the outgrowth of these years of experience and give, as a rule, satisfactory results. There occurs, however, from time to time serious damage to trees and fruit. The use of this method has increased enormously with the betterment of the citrus market during the last few years, and it becomes of great importance to all citrus growers to have fumigation placed upon an exact basis to give it its greatest efficiency and to remove or greatly lessen the likelihood of any bad results. This investigation will be carried out during the fiscal year 1908 in southern California under the direct supervision of Mr. C. L. Marlatt, and will include a thorough survey of existing

conditions from the insect side, and also an examination of current practice throughout the district. In the fall and winter there will be conducted field tests of fumigation to discover the best formulas and methods from the standpoint of efficiency and the freedom from ill effects of trees and fruit. In this investigation the Bureau of Entomology will have the cooperation and assistance of the Bureaus of Chemistry and Plant Industry of the Department.

With the boll weevil, the reduction in the appropriation for the investigations by this Bureau prevents the work of this fiscal year from being conducted on as broad lines as was intended, but many of the important lines that have been under way and that have been suggested by recent investigations will be continued. The experimental field work now going on is located at seven points in Texas, one in Arkansas, two in Louisiana, and one in Indian Territory. Two hundred and thirty-eight acres will be utilized under contract, and the use of about as much more has been granted by private parties. The work is all being located in regions where the greatest damage may be expected. The general work of the investigation is divided into 26 distinct projects, to which different men are assigned and for which they become responsible. Among these projects are a further study of the flight of the boll weevil and its bearing on control and quarantines; life-history studies in the Red River Valley in Louisiana sufficiently comprehensive to reveal points which will necessitate changes in the system of control perfected in Texas; the exhaustive investigation of insecticide control in the light of discoveries recently made; a study of the possibility of attracting the weevils in the fall or in the spring by food supply and shelter; a study of the climatic control of the weevil with reference to probable future damage; an investigation of cultural practices in relation to control of the weevil; a continuation of experiments and observations on the most favorable time for fall destruction of plants, and the relative effectiveness of this operation at different times; study of new types of machinery designed for weevil control, and other lines of equal or lesser promise. Special efforts will be made in the practical utilization of the information that has been obtained regarding parasites and predaceous enemies of the weevil. Shipments of parasites will be sent from Texas to the infested region in Louisiana. In cooperation with the Louisiana crop pest commission, an agent has been stationed at Shreveport, La., to assist in this work. A series of special experiments will be carried out in Texas in inducing parasites of related weevils to attack the boll weevil. Cooperative work is under way, in connection with the Mexican authorities, having a bearing upon the study of the parasites, and Mexican parasites will be sent to the United States in a much more systematic way than has been possible in the past.

The work against the gipsy moth is at this time of writing well under way, and consists in the continuation of the methods adopted for the previous fiscal year. Following the spraying work, the cleaning up of roadsides will continue, and as the winter approaches scouting and the destruction of egg clusters will follow.

With regard to parasites, arrangements have been made so that European material will continue to be received practically through-

out the year. With the conclusion of the gipsy-moth caterpillar season in Europe, brown-tail moth eggs will be received; the predatory Calosomas will continue to come up to autumn; gipsy-moth eggs will be received during the autumn; and brown-tail moth nests during the winter. With the opening of the season will begin shipments of larvæ of both brown-tail and gipsy moths. A further effort will be made to introduce the Japanese parasites by correspondence, and, if necessary, with the cooperation of the Massachusetts State authorities, an agent will be sent to Japan for this purpose. The parasite-laboratory at North Saugus, under the control of the Massachusetts State authorities, will be changed in location and much enlarged, in order to accommodate more workers and in order to handle the greatly increased amount of parasitic material coming from Europe under the joint auspices of the Bureau of Entomology and the Massachusetts officers.

The work in regard to forest insects has been carried on almost entirely in the direction of projects already begun, and the same may be said for the work on grain insects, with the exception of the new Pacific Coast station referred to above. An investigation of alfalfa insects will be included.

With regard to the white fly, the investigations of the past year have laid a good foundation for an exhaustive study of the whole problem with a satisfactory outlook. The general work of the present fiscal year will follow the lines already indicated, but the increased funds provided by Congress will make it possible to conduct the experimental field work on a much larger scale and thus secure practical results of much greater value. Measurably conclusive results from experimentation with means of control, both by spraying and gassing, should be reached within a reasonable length of time, and possibly by the end of the next year's work. The work with fungous diseases will take more time, in all probability, and the introduction of parasites will also require additional time. The absence of parasites and important natural means of control other than fungous diseases in the white-fly districts of the Gulf region warrants the expending of considerable effort to promote the introduction of parasites, particularly as the horticultural conditions of Florida are such that concerted action with the usual remedies will be very difficult.

In bee culture bee diseases will continue to be the subject of most importance for investigation. The bacteriological work which has been begun so favorably will be continued, and detailed studies will be made of the various micro-organisms found. Inoculation work will be continued on a large scale, and an attempt will be made to determine the cause of European foul brood. All of these investigations will point toward improved methods of treatment. A bulletin on the practical control and inspection of bee diseases will be presented during the year. Investigations looking toward the discovery of the cause of swarming and leading to work on swarming control will be undertaken, and experimental work upon queen mating will also be undertaken.

The other work of the Bureau will consist in carrying on the investigations already begun.

**SUGGESTIONS AS TO WORK RECOMMENDED FOR THE FISCAL YEAR
ENDING JUNE 30, 1909, FOR USE IN PREPARING ESTIMATES.**

As the work upon the various projects entered into continues, opportunities are seen in many instances where more assistants can be used to advantage in the hastening of important results, and with the employment of further assistants comes the necessity for larger funds for expenses. It therefore seems most desirable that the fund for general entomological investigations be increased from \$113,800 to \$150,000. This will enable additional men to be employed and will extend these important investigations in a way to insure greater efficiency, and thus, naturally, increase the speed in the accomplishment of practical results. Should this additional appropriation be made, the increased amount will be divided among the different lines of work in the directions in which such increase is seen to be most needed.

With regard to the boll-weevil investigations, it is not considered by the Bureau that the problem is by any means completely solved. It is believed that more effective means of control than those now known may be discovered. In regions that are now being invaded or almost to be invaded there is urgent need for methods to meet the new conditions. The pest has caused the actual abandonment of land in some parts of Texas, and where this has occurred the conditions approach those in regions now being invaded. The work already done along some lines, notably with parasites and predatory enemies, has just reached the stage where most important results may be expected. This work, in the nature of the case, must go slowly, but it should be prosecuted until every possibility has been exhausted. Isolated colonies ahead of the territory that will be reached naturally in several years are increasingly likely to be found, and the immediate eradication of one of these would mean a saving of many thousands of dollars to the locality concerned. For the reasons given above, it is considered that the situation urgently demands a continuance of the present appropriation of \$40,000, and that it would be wise to provide an additional amount of at least \$10,000 to be used in case isolated advance colonies should come to light.

In the work of preventing the spread of the gipsy moth and the brown-tail moth, the results obtained have been so excellent as to show thoroughly the practical value of this appropriation by the General Government. The spread could be still more effectively checked and the infested area be more rapidly reduced in direct proportion to the expenditure of more money. It is the urgent desire of the inhabitants of the infested region that more work should be done by the Government. In view of results, this desire seems reasonable, and an increase of \$100,000 is therefore recommended in the sum to be devoted to preventing spread of moths—\$250,000 instead of \$150,000.

In regard to salaries, I respectfully urge that two additional clerks of Class 3 be added to the statutory list. Prior to 1905 one such position was contained in the list, but was dropped that year. The object of this recommendation is to establish on this roll a proper opportunity for promotion which does not exist at present. Owing to the increased activities of the Bureau a larger clerical force is needed, and the lower positions made vacant by promotions

could be filled with new employees. There are on the roll at present two skilled stenographers of long service and of the most deserving character who should have been promoted to the third class before this. The addition of these two clerks will therefore allow a sufficient increase in the clerical force and at the same time permit the deserved promotions. I further recommend that the salary of the chief clerk of the Bureau be raised from \$1,800 to \$2,000 per annum. This will place the salary of this employee more nearly on a par with the corresponding positions in other Bureaus, and the promotion is thoroughly deserved. I also respectfully urge that the salary of the Chief of Bureau be increased to \$5,000. The importance and scope of the work conducted in the Bureau are such as to warrant this increase.

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Bureau of Entomology.

U. S. DEPARTMENT OF AGRICULTURE.

REPORT
OF
THE ENTOMOLOGIST
FOR
1909.

BY
L. O. HOWARD.

[FROM ANNUAL REPORTS OF THE DEPARTMENT OF AGRICULTURE.]



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REPORT OF THE ENTOMOLOGIST.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., August 11, 1909.

SIR: I submit herewith an executive report covering the work of the Bureau of Entomology for the fiscal year ending June 30, 1909, dividing it, in accordance with your instructions, under the following headings:

(1) A summary of the important operations carried on during the fiscal year ending June 30, 1909.

(2) An outline of the plans proposed for work during the fiscal year ending June 30, 1910, under appropriations already made for that year.

(3) Plans of work recommended for year ending June 30, 1911.

Respectfully,

L. O. HOWARD,
Entomologist and Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

WORK OF THE YEAR.

The work of the year beginning July 1, 1908, and ending June 30, 1909, may be classified, with some modification from the classification of previous years, as follows:

- (1) Work on the gipsy moth and the brown-tail moth.
- (2) Importations of useful insects.
- (3) Exportations of useful insects.
- (4) Work on insects injurious to southern field crops.
- (5) Investigations of insects damaging forests.
- (6) Investigations of insects damaging deciduous fruit trees.
- (7) Cereal and forage-plant insect investigations.
- (8) Work on insects injurious to vegetable crops.
- (9) Work on insects affecting citrus fruits.
- (10) Investigations of insects in their direct relation to the health of man and domestic animals.
- (11) Work on insects injurious to stored products.
- (12) Inspection work.
- (13) Work on bee culture.
- (14) Unclassified work.

WORK ON THE GIPSY MOTH AND THE BROWN-TAIL MOTH.

Few innovations in the methods of the work on the gipsy moth and the brown-tail moth, as described in previous reports, have been made during the past year, and the work accomplished in preventing the spread of the moths has been quite satisfactory. They have been held within the bounds established a year ago, except in the State of New Hampshire, where a number of localities of occurrence have been discovered to the north of the region formerly known to be infested. It is not likely that a very great spread has occurred during the year, as most of these localities are places hitherto undiscovered but which have been infested for some time.

As in other years, the Bureau has cooperated to a great extent with the state officials of Maine, New Hampshire, Massachusetts, Rhode Island, and Connecticut. As in previous years, governmental activity against the brown-tail moth has been quite limited, since all of the infested States have laws which require property owners to destroy this insect on private lands and requiring the municipalities to take care of the trees along highways.

The fight against the gipsy moth has been carried on continuously throughout the year in conformity with all the best known methods.

WORK IN MASSACHUSETTS.

In Massachusetts, which remains the most seriously infested of all the New England States, the agents of the Bureau have continued cutting underbrush and removing dead wood and undesirable trees to a distance of 100 feet back from the roadway on either side of the roads leading through the worst infested woodlands. Down to the close of the fiscal year about 300 miles have been cleared in this manner, and along the roads where this has been done the foliage was, on July 1, 1909, in nearly perfect condition, making it practically impossible for caterpillars to drop from trees anywhere through this section upon passing vehicles. In a few places the caterpillars on the foliage of trees on cleared roadsides were so numerous, especially on overhanging trees, that many of them were blown, as they hung suspended by silk, into trees which were being cared for, so that an additional strip of about a rod in width was cleared as a precaution to the roadside strips.

In addition to the cutting and pruning necessary, these strips have been sprayed with arsenicals, and much additional territory has also been thoroughly sprayed in localities where it has not been possible to clear roadsides.

Trees in the worst infested localities have been banded with tangle-foot and the caterpillars found below the bands have been destroyed daily. In some of the worst infested places the trees have been examined twice each day, in order that the caterpillars might be killed and thus kept from crawling out into the roads, where they could easily be picked up by vehicles.

Where the caterpillars were not so numerous, trees have been burlapped and the bands turned over when it seemed to be necessary. Occasionally property owners have objected to the amount of cutting needed, but in most cases they have been so well pleased with the result that they have cleared large tracts of underbrush at their own expense. Several towns in Massachusetts are also adopting the methods of the Bureau in caring for roadsides within their limits.

WORK IN NEW HAMPSHIRE.

During the summer of 1908 scouting operations in the woodlands of New Hampshire were continued with a force of 10 men. About November 1, when the leaves began to fall, additional trained scouts were sent into the State, who were among the most expert members of the force in searching for the frequently inconspicuous egg clusters of the gipsy moth. About 100 men were occupied in this way until the eggs began to hatch in May, 1909. This thorough scouting has revealed the presence of the gipsy moth in over 100 towns in the State of New Hampshire.

The infested territory in this State now includes all of eastern New Hampshire south of Lake Winnepesaukee, with a strip 2 or 3 miles deep west of the Merrimac River. The territory south of a line drawn from Dover to Nashua is badly infested, and from the present outlook there does not seem to be much hope of improving conditions under state supervision. In order to hold the gipsy moth in check in New Hampshire, the great bulk of the work must be done by the General Government, at least until additional appropriations can be made by the state legislature.

In addition to the territory found to be infested in all cases at least one town beyond the limits of the area known to be infested has been scouted, as well as territory even beyond these towns where there was any reason to suspect the occurrence of the insect.

The main route of travel for summer tourists up the Pemigewasset valley to the White Mountains, and the route from Ossipee to the mountains, as far as Bethlehem and Bretton Woods, has been gone over very carefully. No indication of the gipsy moth was found north of Ossipee, on the eastern route, nor north of Meredith, on the western route. During this scouting the men destroyed by creosote 371,102 egg clusters, and as each egg cluster contains about 500 eggs a potential army of gipsy moth caterpillars of great size was destroyed. During the summer and autumn a few miles of the roadside cutting, similar to that done in Massachusetts, was carried out.

WORK IN MAINE.

In Maine the state authorities carried the pay roll of the men engaged in the work until their funds became practically exhausted. The state organization was then taken over on the government pay roll, and most of the scouting work was done by the Bureau during the winter of 1908-9, in addition to such summer assistance as it was able to give. Down to the autumn of 1908 efforts in the State of Maine against the gipsy moth have been confined to orchard and roadside work, but during the past winter much woodland work was begun, and several colonies, some of which contained thousands of egg clusters, were carefully cleaned up, the underbrush was cut, trees were pruned, and the infested areas were put in condition for the coming summer campaign. Although more egg clusters were found during the past winter than during the previous year, the infested territory in Maine is now in better condition than it has ever been. The Government is assisting the State in the summer burlap work by carrying a large proportion of the state men on the Bureau pay roll.

The outbreak of the gipsy moth at the soldiers' home, near Augusta, seems to have been overcome, and the outlook for the whole State is encouraging.

WORK IN RHODE ISLAND.

The infested territory in Rhode Island shows continued improvement. During the winter of 1906-7, 80,000 egg clusters were discovered and destroyed. During the winter of 1907-8 only 7,500 could be found, and these were destroyed. During the past winter (1908-9) less than 1,700 egg clusters could be found, which indicates that the insect is rapidly approaching a condition of absolute extermination.

The State has been receiving practically the same assistance as the State of Maine. During the period when the state funds were available the operators were paid by the State, but during the remainder of the year they were carried on the federal pay roll.

During the summer of 1909, 150,000 trees were burlapped, and about fifty of the men caring for these burlapped trees have been carried on the federal pay roll.

During the past winter all of northeastern Rhode Island was carefully scouted, and no additions were found to the previously infested territory. Two towns previously infested have shown no indications whatever of the moth during this scouting, and in another town but one previously known colony continued to show evidences of the existence of the pest.

WORK IN CONNECTICUT.

As in previous years, the State of Connecticut has practically conducted its own campaign. But one large colony was ever known in this State, namely, in the vicinity of Stonington, and aside from sending one of the best federal scouts to that locality for two weeks, the State has not asked for assistance. But six egg clusters were discovered there during the past winter, and down to June 30 only 76 caterpillars were found. There seems to be every hope of the absolute extermination of this colony in the near future.

EXPERIMENTAL WORK.

Although perfectly satisfied that the methods adopted are sound, considerable experimental work has been carried on during the year, with a view of discovering easier and cheaper methods of handling the pest than had theretofore been known. In the course of this work several important discoveries have been made. It has been shown, for example, that pine trees can be protected by a tanglefoot band, even though carrying many egg clusters above the band, since it seems that the young caterpillars do not eat the pine needles, but drop from the trees in search of more tender food until such time as their jaws become sufficiently strong to eat pine leaves.

Experiments with different arsenical mixtures, with different pump pressures, and with different distributing apparatus, as well as experiments in the distribution of dry arsenate of lead upon wet foliage, have been carried out.

An important step in preventing the further spread of the gipsy moth has been taken in cooperation with the different railroad corporations operating within the infested territory. As the result of this cooperation an embargo notice against the shipment of lumber, cord wood, fence posts, railroad ties, and similar forest products went into effect July 1, 1909. The notice issued by the railroads

places upon the shipper the responsibility of requesting inspection when such products are offered for shipment and of presenting a certificate of inspection to the railroads before they will accept the shipments. It is hoped in this way to eliminate such danger as may be threatened through these transportations.

THE BROWN-TAIL MOTH IN NEW YORK.

A small infestation of the brown-tail moth was discovered late in June near Port Chester, N. Y., just across the Connecticut state line. Only a few larvæ were found, and the infested area has been thoroughly burned over and sprayed by the state entomologist, Doctor Felt. No expense has been spared in the attempt to exterminate the insect at this point.

IMPORTATIONS OF USEFUL INSECTS.

As in previous years, the principal efforts of the Bureau in importing useful insects have been devoted to a continuation of the very large scale experiments in introducing from different parts of the world into New England the parasites and predatory enemies of the gipsy moth and brown-tail moth. The parasites have all been received at the gipsy-moth laboratory supported by the State of Massachusetts at Melrose Highlands, Mass., and their care has been assigned, as in previous years, to Mr. W. F. Fiske, of the Bureau.

As explained in the annual reports of the Bureau for the years 1905 and 1906, this work has been distinctly in cooperation with the State of Massachusetts, which has appropriated specific funds for the purpose. In 1905 Congress appropriated the sum of \$2,500 for this work, but Massachusetts the same year made a much larger appropriation, and with the consent of the Secretary of Agriculture the Chief of the Bureau of Entomology was placed in charge. During the earlier part of the experiment nearly all of the expense attached to the work was paid by the State of Massachusetts. As the experiment has grown in size, however, it has been found necessary to assign a constantly increasing number of expert assistants from the Bureau of Entomology, until at the present time the General Government is expending in the work about as much as the State of Massachusetts. To the State, however, belongs the credit of having practically instituted the work and for having generously supported it in its full progress.

The writer visited Europe in May and June, 1909, and started forwarding agencies for parasites at Cherbourg, France, and Hamburg, Germany; visited agents and officials in Holland, Germany, Russia, Austria, Hungary, Switzerland, and France; studied the European situation thoroughly, discovered a new and most favorable locality in France, which will be worked to the utmost next summer, and secured largely increased sendings of parasitized material from many points.

Prof. Trevor Kincaid, of the University of Washington, at Seattle, who was sent to Japan during the spring and summer of 1908, and who had, by his successful shipments demonstrated his great ability in this direction, was sent to Russia in April, 1909, in order to secure as many as possible of certain apparently important parasites previously sent over by Russian agents and correspondents. Owing to

various unforeseen conditions, and principally owing to deficient transportation facilities, the material received as the result of his expedition proved to be unsatisfactory on the whole.

Upon Professor Kincaid's own advice it was considered unnecessary to send a second expedition to Japan during the summer of 1909, since the Japanese entomologists had exhibited such a hearty and intelligent interest in the experiment, and the Japanese Government had shown itself so favorably inclined to assist. After a preliminary correspondence between the Secretary of Agriculture of the United States and the minister of agriculture for Japan, Prof. S. I. Kuwana, of the imperial agricultural experiment station at Tokyo, was designated by the Japanese Government to be its official representative in work to be carried on during the spring and summer of 1909. Professor Kuwana has shown himself to be a man of extraordinary intelligence and activity, and a number of interesting and valuable lots of parasitic material have been received from him at the laboratory at Melrose Highlands, Mass. This material was received in uniformly good condition, and this was due to the great care and intelligence shown by Professor Kuwana in its collection and the method of packing and shipping. The hearty thanks of the United States Government are due to the Japanese Government in this matter, and warm individual commendation and thanks are due to Professor Kuwana.

The most perfect service of the present summer was secured in France. Arriving in Paris on the 13th of May, the writer met, by appointment, Mr. René Oberthür, of Rennes, a French entomologist of high standing, and certain of his collaborators. Plans were considered, largely at the suggestion of Mr. Oberthür, which resulted in the institution of a very large scale service, principally in the south of France, and in the employment of a large number of collectors under expert supervision. From this arrangement several thousands of boxes of good material were received at the Melrose Highlands laboratory from this region. In quantity it exceeded the total of all other importations of a similar character made since the inception of the work, and from it have been reared a greater number of important Tachinid parasites than have been reared from all other importations of similar character taken together. Mr. Oberthür has taken up this work voluntarily as a private citizen of France, wholly without compensation, and entirely from his scientific and practical interest in a great piece of experimental work. The warm thanks of the United States, and particularly the New England States, are due to this remarkable man.

Another notable importation of the year consisted of several thousand egg-masses of the gipsy moth received during the winter from Prof. Josef Jablonowsky, director of the entomological station under the ministry of agriculture of Hungary at Buda-Pest. These were collected in various localities in Hungary, and after their arrival in Massachusetts there were reared from them and liberated under the most favorable conditions more than 75,000 egg-parasites of the species known as *Anastatus bifasciatus* Fonsc. This is especially noteworthy, since less than 1,000 of these parasites had previously been received from all localities, the earlier ones having come from southern Russia and from Japan.

In addition to these more or less unusual shipments, quantities of miscellaneous material have been received, for the most part in good condition, as formerly, from numerous collectors in Germany, Austria, Italy, Holland, Belgium, and Switzerland. Eggs, caterpillars, and pupæ of the gipsy moth, hibernating webs, caterpillars, and pupæ of the brown-tail moth, and adult predaceous beetles have been included in these shipments.

In beginning this large experiment in the importation of parasites there were three principal factors to be considered. First, the importation of living and healthy parasites in numbers sufficient to admit of colonization. For the most part this question has been solved, and the work of importation has become a mere matter of routine. The second question was the handling of the parasitic material after its receipt at the laboratory; and the third, what to do with the imported parasites in the field and how to ascertain results. The second problem, namely, how best to handle the parasitic material after its receipt, has also practically been solved. During the earlier years much time and trouble was expended in attempting to devise methods for doing what had never before been attempted upon a very large scale, but at the present time a comparison between the situation and that of four years ago shows that a large bulk of this work, like that of parasite importation, has resolved itself from a tedious and costly experimentation into a matter of routine. Improvements are to be expected and are being discovered. Attempts to secure reproduction of parasites under laboratory conditions have succeeded in a great majority of instances, and in a few wholesale breeding on a large scale has proved economically possible. *Pteromalus*, which attacks the hibernating caterpillars of the brown-tail, several brown-tail egg parasites, a newly imported egg parasite of the gipsy moth, and *Calosoma sycophanta*, a large predatory ground-beetle, have all been brought under complete laboratory control, and the numbers which it is possible to rear and colonize seem limited only by the expense of the work. The brown-tail egg parasites, however, seem not to be of as great economic importance as supposed.

A newly imported parasite of the gipsy moth eggs was received from Japan in the spring of 1909, for the first time in a healthy condition. Less than a score of these individuals, reared from these imported eggs, have been increased, through careful laboratory management, to more than 2,000, and it is confidently expected that enough will be reared before the close of the present year to allow a test of the efficiency of this parasite in the field.

With the *Calosoma* beetle the laboratory work during 1907 and 1908 has resulted in the complete laboratory control of the species, and a maximum of reproduction with a minimum of loss has been secured this year. In addition to a number of beetles imported directly from abroad, 6,000 larvæ have been reared in the laboratory and colonized, 100 or 200 in a place. Several other species of predaceous beetles have been imported, and, in some instances, colonized. With one or two possible exceptions, their disinclination or inability to climb into the trees in search of their prey make them of little value in the control of the gipsy moth, although when given the opportunity they will feed upon the larvæ and pupæ freely. Reproduction of several Tachinid parasites of the gipsy moth and brown-tail moth

has also been secured in the laboratory, and work upon the biology of these parasites conducted by Mr. Townsend has resulted in many surprising discoveries which will have an ultimate practical effect.

The problem of colonization of laboratory-bred material and other material and the study of the imported parasites in the field is still open to a great deal of work. The statement made in the last annual report that "it is altogether likely that the species introduced had found conditions favorable to their increase, and that at the present time they exist in considerable numbers," has been strikingly upheld in one instance. A hymenopterous parasite (*Monodontomerus*), which attacks the pupæ of both the gipsy and brown-tail moths, was first recovered from the field in the early winter of 1908 and 1909, but has since been found fairly evenly distributed over the area of approximately 500 square miles. A similar rapid increase, rendered unnoticeable on account of an equally rapid and very widespread dissemination, can not be expected in every instance, but it is not unreasonable to suppose that it may occur in several.

Recent field work has discovered indications of a considerable spread of *Calosoma* from the immediate neighborhood of the original colonies, and it seems obviously only a question of a very short time before it will be distributed throughout the entire area covered by the gipsy moth.

Twelve species of introduced parasites and predatory species have been recovered from the field this year, as against six last year, although not all of these have demonstrated their ability to pass an entire year under their new geographical environment.

There have been imported in all, according to present classification, twenty-six species of Hymenopterous parasites. Of these, one or two are probably identical, although recognized under different names as they come from Europe or Japan. At least twelve of these are of very little promise. Some of them have been given thorough tests in the field, and others, on account of their exceeding rarity in connection with the gipsy moth or brown-tail moth, or for other reasons, can not be considered as important. There remain twelve, of which eight have been received in numbers sufficient to admit of the establishment of satisfactorily large and strong colonies. Nearly all of these have been recovered after at least one generation under natural conditions in the open, but not all after a complete year has passed. One more is soon to be liberated. The remaining three have never been received alive in numbers sufficient to admit of satisfactory colonization.

Of the twenty-nine species of Dipterous parasites mentioned in the last report as having been reared from the gipsy moth or brown-tail moth, a certain number may be eliminated for similar reasons. There are about seventeen of varying importance, all but two or three of which are, to all practical purposes, confined to either the gipsy moth or the brown-tail moth. Fifteen, at least, seem to be of economic importance in this connection. All of these have been colonized more or less extensively, and three of them have been recovered from the field.

The close of the present year finds us with twice as many species of introduced parasites available for study in the field as we had last year. Instead of being confined to exceedingly limited areas in the vicinity of the original colonies, several of them are scattered over

extensive areas, and it is hoped by the continuance of the same and improved methods that this number will be increased during the present year. By a more close following of the increase and spread in the field we may be able to more accurately prophesy upon the probabilities as to the time of the reduction in numbers of the pest than we have heretofore been able to do.

OTHER IMPORTATIONS.

In the last report the successful introduction of a European parasite of the imported elm leaf-beetle was announced. Examinations made at points of colonization during the present summer have failed to indicate that the insect successfully passed the winter. It is possible that it may have established itself in localities unvisited this year, but it has not been as successful as was hoped. Attempts to reimport the species this year have failed, owing to its absence in certain European localities and to the untimely death of Prof. Valery Mayet, of Montpellier, France, occurring at the time when he expected to make shipments to the United States. Through the cooperation of Prof. F. Silvestri, of Portici, Italy, unsuccessful efforts have been made to introduce two other natural enemies of the imported elm leaf-beetle.

European codling-moth larvæ were imported from different parts of Europe, especially from Germany, in considerable quantities during the fall and winter, and the work of rearing them was continued at the gipsy-moth parasite laboratory at Melrose Highlands, Mass. The expert in charge of the work found a very scant percentage of parasitism of the material received, though a large percentage of the larvæ succumbed to the attack of a fungous disease.

EXPORTATIONS OF USEFUL INSECTS.

In my last report I called attention to the fact that while the Bureau desires to return the many favors that foreign entomologists have extended to this country by sending them beneficial insects which may possibly be of service to them, this can be done comparatively rarely, but the occasion has arisen several times, and has justified the attempt.

Mention has previously been made of the exportation of certain important parasites of *Diaspis pentagona*, a scale insect attacking the mulberry in southern Europe, which have been sent to Italian officials, and it is a great pleasure to report the apparent success of one of these exportations. Prof. Antonio Berlese, director of the Royal Station of Agricultural Entomology, at Florence, writing under date of July 10, 1909, informs the Bureau that one of these parasites has already spread through the mulberry trees of Vanzago and has entirely relieved them from the destructive scale. The parasite is now being distributed from this district into other similar localities, and it is Professor Berlese's expectation that in two years relief for all Italy will be effected. Further, it has just been learned that through sendings to Prof. F. Silvestri, of Portici, this parasite has been acclimatized at Acerra, Grottamare, and Palombino, Italy.

During the winter of 1908-9 certain ladybird beetles collected in southern California were sent by the Bureau to Malaga, Spain, for

the purpose of preying upon a species of mealy bug. Success has as yet not been reported.

During the summer of 1909 parasites of *Diaspis pentagona* have been sent from Washington to Peru, in an experimental effort to ascertain whether they will successfully parasitize a closely allied scale insect which is greatly damaging the cotton crop in that country.

Other beneficial ladybird beetles have been forwarded by the Bureau to southern Italy, in an effort to acclimatize them as enemies of destructive scale insects.

A new species of tick parasite occurring upon a dog tick in Texas, related to the cattle tick and referred to in a later section of this report, has been sent in considerable numbers to South Africa, in order to ascertain whether it will attack certain congeneric species which are among the most important disease-transmitting ticks in that country.

No further reports have been received as to the success of the exportation of the American sand-digging wasp to Algeria to kill the Tabanid flies which transfer a trypanosome disease of the dromedary, as mentioned in the last annual report of the Bureau. Nor has any further attempt been made during the year to export bumblebees to the Philippine Islands. Dr. P. C. Freer, director of the bureau of science at Manila, states that in April, 1909, descendants of the first importation were found in small numbers in the vicinity of the place where they were liberated in 1908.

WORK ON INSECTS AFFECTING SOUTHERN FIELD CROPS.

The work on insects affecting southern field crops has previously been reported upon in annual reports of the Bureau under different headings and is now, for the sake of convenience, brought together. The whole work has been carried on under the supervision of Mr. W. D. Hunter.

THE MEXICAN COTTON BOLL WEEVIL.

The Mexican cotton boll weevil destroyed at least 400,000 bales of the crop of 1908, of a value of at least \$20,000,000. The most noteworthy feature of the situation during the year was the fact that the damage in Texas was light compared to that in Louisiana and in the small portion of the State of Mississippi that had been invaded. Weather conditions in Texas reduced the numbers of the hibernating weevils considerably, but the opportunities for hibernation in the eastern region were so favorable that great numbers survived. Moreover, dry weather during the growing season in Texas retarded the development of the insect, while no such check occurred in Louisiana. Therefore the bulk of the loss fell upon the State of Louisiana. It is perfectly clear that the situation in Texas was abnormal, and that greater damage must be expected whenever the climatic conditions of the winter and spring are more favorable to the weevil. The great loss suffered in Louisiana is a verification of the prediction that has been made by the Bureau of Entomology for several years and indicates the importance of devising means of control adapted to such conditions as are found in Louisiana, Mississippi, and other States that will soon be invaded by the weevil.

Experimental farms.—The general plan of work on the experimental farms that has been followed for several years was continued during the fiscal year. The object of these experimental farms is to apply, under practical field conditions, the results of observations in the laboratory and elsewhere that seem to indicate means of control. New points are being discovered continually. For this reason it is highly desirable to continue the work from year to year. Moreover, in many cases it is necessary to repeat experiments in control through a series of years to determine their relative effectiveness under vicissitudes of different seasons. The experimental-farm work of the Bureau during the fiscal year covered about 300 acres, located at selected points throughout the infested territory.

Utilization of the insect enemies of the boll weevil.—The insect enemies of the boll weevil have come to be of great importance. A large number of examinations were made to determine the mortality rate due to this cause in 1908. It was found in one case that 77 per cent of the boll weevils in a field in Louisiana were being destroyed by their insect enemies. At various points in Texas from 21 to 48 per cent of the weevils were killed in the same way. These records are based on the examinations of many thousands of weevil stages, and indicate the general extent of control brought about by parasites. It is evident that the extent of control secured in this way is much greater than that at the command of the planter by any artificial means. Moreover, it has been found feasible to make certain changes in planting and cultivating systems that will facilitate greatly the work of the enemies of the weevil. Experiments in introduction from one region to another have been made with good success, but it is considered that the most important feature of the parasite situation is to devise means that can be resorted to by the planters to increase their effectiveness. The method of planting, the varieties planted, the spacing of the plants, the methods of cultivation, and the methods of gathering the crop, all have a bearing upon control by parasites. Each one of these features has been investigated and certain recommendations have resulted. The subject is a large and complicated one, dealing with changing conditions, and will require additional work for several years.

In the way of introduction of parasites from one locality into another, encouraging progress has been made. In one experiment the mortality in hanging squares was increased from 9 to 37 per cent by the introduction of parasites from another region. Of course, this experiment was checked by a similar area in which no parasites were introduced. In several cases of this kind parasites that originally did not occur in certain regions were established and in all probability will increase their effectiveness and spread from year to year.

The chain cultivator and other machines for control.—Mention of this device was made in the last annual report. Tests during the season of 1908 demonstrated the effectiveness of the implement. Its use was found to have a practically immediate effect in increasing the death rate of the weevil due to the heat and also indicated great practical value as a cultivator. In fact, it is likely that the use of the implement would be warranted for its cultural effect even if no weevils were destroyed. The implement was examined carefully by

the president of one of the large manufacturing concerns of the country. As a result the company has manufactured a number of machines that have been placed upon the market.

It was discovered during the season that an implement constructed on the principle of the chain cultivator, but with runners of wood instead of chains, might also have an important effect in the control of the weevil. In fact, the wooden implement will probably be found better adapted to some conditions than the chain cultivator.

Special studies in the Mississippi Delta.—For some years the greatest damage by the boll weevil will undoubtedly occur in the States bordering on the Mississippi River. The first season after the original invasion by the weevil in that region has frequently shown a falling off of 50 per cent in the crop. This is much more than the damage done under similar conditions in Texas. The causes for this situation are the precipitation, presence of heavy timber, mild winters, and other features. These all combine to give the boll-weevil problem more serious features than it has had elsewhere. This prediction of special damage was made several years ago by the Bureau of Entomology, and the findings in the delta region during the last year have demonstrated fully that the danger was not overestimated.

One of the most hopeful features in the delta region is a utilization of parasites, but all other means of control must be taken into consideration. For this reason special experiments and observations were made on the life history of the weevil in the Delta. This included experiments in hibernation in the neighborhood of Natchez, Miss. The work in this case was planned primarily to determine what may be accomplished by the destruction of plants at different dates. It is the general impression of planters in the Delta that the destruction of plants will not be as effective as in Texas.

Work on status of weevil.—There is a regular and proper demand for information regarding the status of the weevil and the amount of damage that may be expected. It devolves upon the Bureau of Entomology to furnish this information. To do so requires the examination of many cotton fields at different times during the season, the comparison of the records with those of previous years, and the dissemination of the data thus obtained. This work was continued during the year.

General laboratory work.—In the laboratory of the boll-weevil investigation at Dallas, Tex., many experiments were conducted that were later carried into the field. In fact, whenever anything is discovered in the laboratory in the study of the life history of the weevil or its parasites that furnishes a clew to control, the matter is immediately taken up under practical field conditions. The life history of the weevil is now pretty well understood; therefore the principal work during the season was in connection with the propagation of parasites. In addition, of course, the records of all the experiments outside of the laboratory were kept there, and large numbers of parasites were studied, reared, and disseminated.

Testing proposed remedies.—Many persons continue to offer suggestions about the control of the weevil. These frequently take the form of special preparations, such as poisons. It was necessary, therefore, during the fiscal year to make a number of tests for the

information of interested parties and to guard against the extensive sale of useless substances.

Isolated colonies.—As in other years, a constant effort was made to locate isolated colonies far enough ahead of the general invasion to warrant the undertaking of eradication. This was done through field trips and by correspondence with state authorities and others.

TOBACCO INSECTS.

The work on tobacco insects, begun last year and reported upon in the last annual report, has been continued during the year. The main work was carried on in the dark-tobacco region of Kentucky and Tennessee, with headquarters at Clarksville, Tenn. In this region the damage done by injurious insects to the tobacco crop of 1908 is estimated to have amounted to more than \$500,000. The work here was pursued under four main heads: (1) Life history and seasonal studies of the different injurious species; (2) studies of native parasites with a view of increasing their usefulness, and importations of egg parasites of the so-called hornworm from Porto Rico; (3) experiments relating to methods of control; (4) demonstrations of remedies. Under the first heading many important data have been gathered, but the greater time of the investigators has been given to the tobacco hornworms and the flea-beetles, which are the most important pests. It has been found that a spray of arsenate of lead, at the rate of 1 pound of the paste or one-half pound of the powder to 12 gallons of water, is an effective remedy against flea-beetles and also against all other insects attacking tobacco in the plant bed. Paris green at the rate of from 1 to 2 pounds per acre has been found to be effective against the larvæ of the hornworms, but injury to the foliage following this treatment has been reported and experiments with other arsenicals have been undertaken in order to prevent this damage.

Trap cages placed over the flowers of jimson weed were found to capture numbers of moths of the tobacco worm. Fall plowing of land that has been in tobacco during the preceding summer has been shown to destroy 39 per cent of the pupæ of the hornworm that would otherwise hibernate successfully. Cooperative demonstrations of remedies were made at Clarksville, Tenn., and Guthrie and Hopkinsville, Ky.

Additional work was done in Virginia, and during the fall of 1908 a preliminary survey was made at Appomattox, in that State, of damage to tobacco reported to be due to a wireworm. The damage was estimated at \$800,000 for the dark-tobacco district of Virginia. It was shown that the injurious insect is a species of *Crambus*, and an investigation of its life history has been begun.

Although the Bureau had at an earlier date made an investigation of the tobacco thrips in Florida, reports of great damage by planters in Florida brought about a preliminary resurvey during March, 1909. An expert was sent to Florida and visited many growers of shade tobacco at Quincy, and also made collections of thrips to find, if possible, the native food plants and hibernating quarters. From the experiments made it seems possible that the tobacco thrips has a long

hibernating period under ground, like the pear thrips, and if this should prove to be the case the problem of control will be difficult.

During the year, at the request of the tobacco journals, it was decided to make a special investigation of the so-called cigarette beetle. Circular letters of inquiry were sent out during the winter to tobacco manufacturers, and much information was gained. One successful demonstration of carbon bisulphid as a fumigant against this insect was carried on.

OTHER INVESTIGATIONS.

As pointed out in the last report, insects have been found to be an important obstacle to the cultivation of cactus as a farm crop. During the past season it has been found that the damage to the planted cactus has not been overestimated, but that means of control can be put into operation in an economical way. Certain species can readily be trapped in hibernation and burned, and others may be burned upon the plants by the use of torches such as are used in removing the spines, and others may be controlled in other ways. The investigation has practically been completed. Some points require additional study the present season, but it is hoped that the work can be reported upon finally within the next fiscal year.

The necessity for further work upon the insect enemies of sugar cane and rice, as well as upon the so-called Argentine ant, has been forced upon the Bureau, and toward the close of the fiscal year arrangements were made to begin systematic work upon these pests, beginning with the first of July, 1909. These investigations will be outlined later in this report.

INVESTIGATIONS OF INSECTS DAMAGING FORESTS.

The investigations of insects damaging forests, carried on under the direction of Dr. A. D. Hopkins, have been restricted during the past fiscal year more than formerly to the various sections of the country where there seemed to be the greatest need for the work. The more important field investigations of the year have related to the following subjects:

THE WHITE PINE TWIG BLIGHT.

Investigations were carried on in New Hampshire, Maine, and adjoining States, to determine the relation of insects to the several forms of twig blight of the white pine, and incidentally a number of other forest-insect problems peculiar to the New England States were investigated. This has resulted in the determination of some of the causes of the twig blight and the accumulation of many new facts of systematic and economic importance.

INJURIES BY INSECTS TO STORM-FELLED TIMBER.

Investigations were continued in Mississippi and Arkansas on the relation of wood-boring insects to subsequent damage to storm-felled pine timber in the Southern States. This has resulted in the accumulation of evidence to indicate that the storm-felled timber in Mississippi, Louisiana, Alabama, and Arkansas, resulting from the

great storms of 1906, 1907, and 1908, amounted to over 2,000,000,000 feet, board measure, and that during the period in which the timber was sound enough for lumber it was reduced in value 25 per cent by wood-boring insects. It has also been determined that a large percentage of this loss can be prevented, now that the essential details in the habits of the insects are known.

INSECT DEPREDACTIONS IN PRIVATE FORESTS.

Investigations were continued in the private forests of northern California during the summer of 1908 and winter of 1909, in which much new and valuable information was accumulated and on which special recommendations to the owners were based, but further progress toward securing the desired practical demonstrations was prevented by unforeseen personal troubles affecting the field agent in charge of the work.

SULPHUR-FUME INJURY AND INSECTS.

A special investigation was made of the relation of injury by sulphur fumes to previous and subsequent injury by barkbeetles to the timber on private and other lands in the vicinity of Anaconda, Mont., resulting in the conclusion that such relations were of little or no economic importance.

PRACTICAL DEMONSTRATION WORK.

Investigations relating to practical control have been continued in the national and private forests of the central Rocky Mountain region. Special attention has been directed to the securing of statistical data and to the concentration of the cooperative efforts of the Bureau of Entomology and the Forest Service on securing the proper application of the recommendations of this Bureau for the control of extensive depredations by the Black Hills beetle, so as to furnish forcible and convincing demonstrations of the practicability of such control. In all of this work marked success has been attained.

INSECT DAMAGE TO HARDWOOD PRODUCTS.

Investigations of the insects damaging hardwood products and practical demonstration work in their control have been continued, principally in direct cooperation with the more extensive operations in the manufacture of handles, agricultural machinery, vehicles, army and navy stores, etc., and most gratifying progress has been made.

COOPERATION.

Forest entomology and forestry.—The cooperation between the Branch of Forest Insect Investigations of this Bureau and the Branch of Silviculture of the Forest Service comprises the investigation of practical methods of insect control and efforts toward securing the proper practical application of available technical and other information on the insects and local forest conditions in the inauguration of policies of insect control in the various National Forests of the country.

The feature in this cooperation which has yielded most satisfactory results is that in which the Branch of Silviculture furnishes an experienced forest ranger to work under immediate instructions from the forest entomologist in charge of the Branch of Forest Insect Investigations in the location and marking of beetle-infested trees and in securing information on practical and local details to supplement the final recommendations by the forest entomologist for the practical control operations which are conducted by the local forest official under the supervision of the insect-control ranger.

Forest entomology and forest pathology.—While there is no cooperative agreement between the Laboratory of Forest Pathology, of the Bureau of Plant Industry, and the Branch of Forest Insect Investigations, there is a most congenial and helpful interchange of ideas and suggestions, and some cooperative investigations on subjects and problems involving the intimate interrelation of insects and fungi.

Forest entomology and private interests.—A most promising cooperative arrangement for the attainment of immediate practical results from the proper and most economical application of expert information in forest insects and the prevention of losses from their ravages has been effected with certain manufacturers of forest products, in which the company furnishes a thoroughly practical man (who is familiar with the details of manufacturing, handling, storing, and finishing the products that are subject to damage by insects) to work under immediate instructions from the forest entomologist in the conducting of all insect-control and experimental operations that involve, as essential features for their success, a technical knowledge of the insects. In other words, all questions relating to the insects and the essential details on methods of control are decided by the entomologist, and all questions relating to the adjustment of business methods and to local conditions and requirements favorable or otherwise for the practical application of any part or all of the recommendations are decided by the representative of the company. When an agreement is reached all of the expenses of the experiments and practical application in control work are borne by the company.

Cooperation in control demonstrations.—During the latter part of the year certain combinations of circumstances and subsequent information secured through this Bureau led to the activity of a resident of Montana (Mr. Josef Brunner) in calling public attention, through the press, correspondence, and otherwise, to the extensive depredations by barkbeetles in the vicinity of Pine Grove, Mont., and to the need of prompt action under the advice of the Bureau of Entomology. The infestation involved timber on private and state lands, the national forests, and the public domain. This combination of interests, with requests for information and action on the part of the Government, coming from state officials, including both Senators and the Representative, and from a prominent commercial club, presented at once a most interesting and complex situation in which it was plain that nothing whatever could be accomplished without definitely organized effort. Therefore Mr. Brunner was appointed by the Secretary of Agriculture as an agent of this Bureau, to work under our immediate instructions. Mr. Brunner proceeded at once to locate and mark the infested trees and to estimate the cost of the required control operations. He reported that 1,000 infested trees had been

located on private and state lands and 100 on the national forest, and that it would cost approximately 30 cents per tree to cut and bark them to kill the insects. Upon receipt of this report, propositions were made to the Forest Service, state officials, and the commercial club that an agent of this Bureau was ready to proceed with control operations if the required money to cover the actual cost of the operations was provided. The Forest Service promptly appropriated \$100 to cut and bark the infested timber on the national forests. After some delay and the loss of precious time, the parties in charge of the state and private interests indicated their willingness to provide the necessary funds, and at the latest practicable date the control work was started with good prospects for its completion in time to destroy the insects before they emerged to extend their depredations in the remaining living timber.

Whether or not this particular effort succeeds and serves its primary object of demonstration, it opens up new and most promising possibilities for further action along similar lines of direct cooperation between this Bureau and national, state, and private interests, either individually or combined, in securing the desired examples of practical and effectual control through the prompt adoption of the proper and inexpensive methods of procedure. Therefore it should be extended to the full limit of the funds and men available for such demonstration control work.

Forest entomology and state forestry.—The last piece of work of the year related to the consideration of plans for cooperation with a state entomologist in a survey of the State, to determine the principal insect enemies of the forest trees and the character and extent of the damage, in which the State furnishes an assistant to work under our immediate instructions, subject to the approval of the state entomologist. The results are to be published by the State, under joint authorship. This seems to open up another field of opportunity and usefulness in survey and practical control work, by which a State, through the expenditure of a comparatively small sum of money, can secure authoritative advice based on extensive investigation of national and interstate problems, and by which at the same time this Bureau will be afforded exceptional opportunities to disseminate information and make practical demonstrations which will contribute to one of the desired ends, viz, a more general recognition of the importance of the subject and the practicability of preventing losses.

PRACTICAL RESULTS.

Control of the Black Hills beetle.—The permanent value of the successful efforts to control the Black Hills beetle in the vicinity of Colorado Springs and on an extensive private estate in southern Colorado, mentioned in the 1908 report, have been verified by observations during the past year, which failed to reveal any evidence of new infestations.

The practicability of controlling this most destructive enemy of the pine timber of the central Rocky Mountain region, not only without ultimate cost but at a profit on the first cost of the operations, has been demonstrated during the past year on a large private estate and the adjoining Pike National Forest, in north-central Colorado. An examination of the timber in the spring of 1907 by

the ranger detailed from the Forest Service to work under our instructions showed that the depredations by the beetles had been going on for the past ten to fifteen years or more, and had resulted in the death of more than 800,000 board feet of the finest timber. About 65,000 board feet of timber was found to be infested by the beetle at the time of the examination. The owner was notified of the dangerous character of the infestation and the required action recommended to control it, but no action was taken. Another examination of the property was made in the fall of 1907, when it was found that the new infestation resulting from swarms of beetles that had been allowed to emerge from the old infested trees involved nearly four times as much timber, or 240,000 board feet. This alarming increase led to the prompt adoption of our recommendations by the owner and the Forest Service, and by May of the following spring (1908) the small number of trees on the national forest were cut and barked, to kill the insects in the inner bark, and the thousand or more trees on the private estate were felled, the logs converted into lumber, and the slabs burned, which accomplished the desired purpose of destroying the broods of the beetle. The owner realized a sufficient revenue from the timber thus involved to cover all expenses and leave a net profit of over \$1,200. Examination of the area in the fall of 1908 showed that this prompt and properly conducted effort to control the beetle was a complete success. Thus the average death rate of some 100,000 feet of timber annually during the past ten or more years was reduced to a minimum, at a net profit on the cost of doing it.

The cash value of this result, as based on present and future stumpage value of the living timber thus protected in the private and national forests of the entire area coming under the influence of such control operations, is evidently not less than \$50,000, and its value as a demonstration of the absolutely practical and inexpensive method of controlling an extensive invasion of the Black Hills beetle should be worth far more than the cost of forest-insect investigations during the past ten years.

Profiting by the results attained in the control of this beetle in private forests, special efforts have been directed to its control in the Las Animas National Forest and the Wet Mountain section of the San Isabel National Forest, both of which have suffered so severely from its ravages that it is estimated that more than 3,000,000 board feet of merchantable pine has been killed during the past ten years, or an average of about 300,000 feet per year. In addition to infested trees disposed of by the Forest Service in timber sales, 165 infested trees in one section of the Las Animas were cut and barked in May and June, 1908, at a direct cost of \$177.50, and at the same time a considerable amount of infested timber was disposed of by sale in the Wet Mountains. This had a decided effect in checking the ravages of the beetle, and it was followed up the next spring (1909) by the proper disposal of over 1,300 infested trees by free use, ranger labor, and direct expenditure of funds appropriated by the Forest Service. Therefore, the thorough and proper manner in which our instructions were carried out in this case will evidently bring the beetle under complete control, effectually protect the remaining living timber, and, what is more important, serve as an example of the necessity and practicability of insect control in the National Forests.

Control of the mountain pine beetle.—It is evident that if the necessary funds are made available and the extra force of men can be secured to fell and bark the thousand or more trees in the vicinity of Pine Grove, Mont., infested with this near relative of the Black Hills beetle, an equally destructive enemy of the pine timber will be brought under complete control, and this will serve as another demonstration of the possibility of attaining the desired control under an exceptional combination of difficulties.

Progress in the control of powder-post beetles.—The direct answer to a series of questions sent to principal correspondents of this Bureau who have requested information during the past six years on methods of preventing losses from powder post show conclusively that in the numerous cases where our recommendations have been properly carried out most gratifying results have been attained, thus demonstrating the value of such recommendations in actual practice.

INVESTIGATIONS OF INSECTS DAMAGING DECIDUOUS FRUIT TREES.

The investigations of the Bureau against the group of insects damaging deciduous fruit trees have been carried on under the direction of Mr. A. L. Quaintance, and have covered a wide field.

THE PEAR THRIPS.

The investigation of the pear thrips, begun July 1, 1907, soon bid fair to prove one of the most important pieces of work carried on by the Bureau. The damage already accomplished was very great, and that threatened was excessive. While the infested territory is at the present time included within a radius of about 100 miles from San Francisco, the character of the damage is great and the spread of the insect is practically certain. The immediate necessity for competent remedies is striking. Full studies of the life history of the insect have been made and large-scale experiments in all directions have been carried out. The possible value of applications of fertilizers and of soil fumigation, irrigation, etc., to bring about the destruction of the insects in the soil has been investigated without important practical results. Experiments in deep plowing of the soil during the summer to destroy the larvæ, which at this period are all beneath the surface of the ground, gave practically negative results, since the larvæ are active at this period and are quickly able to reconstruct new cells, in which they will live undisturbed. In the autumn, however, it was discovered that deep plowing and cross-plowing with harrowing after the first rains are remarkably effective. At this time the insects are mostly in the helpless pupal stage and are very susceptible to any disturbance. In two orchards in the Santa Clara Valley, where this method was thoroughly tried, there were killed, respectively, 70 and 73 per cent of the insects. Moreover, this process, in addition to its great value in destroying the thrips, is very beneficial, since it puts the soil in better condition to retain water from the winter rains and brings about a more vigorous condition of the trees.

In addition to this excellent result, spraying tests in the spring of 1909 resulted in the discovery that a combination of a tobacco extract in the proportion of 1 to 60 of water with 2 per cent of the distillate oil emulsion produces a perfectly satisfactory spray of

excellent penetrating qualities which kills practically all of the thrips which it touches without any injury whatever to the trees.

Extensive experiments were carried on in the Santa Clara Valley and in the Ignacio and San Ramon valleys in Contra Costa County. Through the material cooperation of the authorities in the counties mentioned, and also that of orchardists, it was possible to conduct the work on a much larger scale than would otherwise have been possible.

It seems that the adults of the pear thrips are for the most part out of the ground and congregated upon the trees before the blossoms have opened to any extent, and it was found that one or two thorough applications of the spray mentioned, under high pressure and directed downward to force the liquid into the bud clusters, will destroy a great majority of the insects present. Careful estimates of the results of this work place the percentage of thrips thus killed at from 90 to 97.

The long period between the swelling of the buds and the actual opening of the flowers in California greatly favors the work of spraying. After the petals of the flowers have spread the insects work inside and are protected.

The spraying operations in both counties were uniformly favorable, and resulted in protecting the blossoms and insuring a fruit crop in orchards in which for some years the crop had been destroyed by the thrips. Several orchardists, acting under the instructions of the Bureau's agents, obtained very satisfactory results, and have expressed full confidence in the entire efficiency of sprays and the method of cultivation described as remedies for the thrips. The use of either or, preferably, both methods in conjunction should give a large degree of freedom from further injury.

In September, 1908, the writer visited California and found the fruit growers practically in despair. One large orchardist expressed himself as confident that nothing could be done and was cutting down a large portion of an orchard valued at \$250,000. The matter had been called to the attention of the State Board of Trade, and the utmost anxiety was felt over the probable spread of the insect, not only throughout all the fruit-growing regions of California, but to the more northern Pacific States, and ultimately toward the East. As the result of two years' work the Bureau feels that the problem is solved, and it only remains to conduct some additional demonstrations and to carry out a few additional experiments before the problem can safely be left to the orchardists themselves. Much credit should be given to the boards of supervisors of Santa Clara and Contra Costa counties for financial assistance in both experimental and demonstration work, and to individual orchardists for cooperation in the use of their orchards.

CRANBERRY INSECTS.

As pointed out in the last annual report, the methods of control of cranberry insects which were more or less satisfactory in the cranberry bogs of New Jersey and Massachusetts were not effective in the bogs of Wisconsin, and cooperative work between the Bureau of Entomology and the University of Wisconsin had been instituted. This work during the past fiscal year has been continued

and enlarged. Owing to local conditions which render flooding of questionable safety, especially in midsummer, attention has largely been given to sprays. The cranberry fruit worm is at present by far the most serious pest in the State, and destroyed last year about 30 per cent of the crop, while in certain bogs from 50 to 65, and even 95, per cent was destroyed. Effective spraying can be practiced only on bogs reasonably clean of grass and weeds, and it has thus been necessary to give attention to the subject of cultural methods. Large-scale spraying demonstration experiments have been carried out in different portions of the cranberry marshes in the Cranmoor district, and have shown uniformly a considerable benefit. Combination sprays of Bordeaux mixture and arsenate of lead have reduced injury by the fruit worm from 60 to 14 per cent. This would be equivalent to a money gain, based on average yield and price, of \$86 an acre. In the spring of 1909 it was planned to do more spraying than last year, in cooperation with cranberry growers, who would provide for a considerable portion of the expense.

THE CODLING MOTH.

Of late much interest has been shown in the one-spray method advocated in the Northwest against the codling moth as applied to the usual schedule of applications followed by eastern orchardists. During the season of 1909 an effort has been made to secure all of the conditions necessary for one-spray work, and tests are being made in Virginia, Michigan, Arkansas, and Missouri to secure data from representative fruit regions as to the effect of variable climatic and other conditions. It is too early as yet to report results.

Extensive experiments were made during the summer of 1908 in the Ozarks, in cooperation with the Missouri State Fruit Experiment Station and the Bureau of Plant Industry of this Department, to determine the relative merits, in the control of insects and fungous diseases of the apple, of liquid and dust sprays. The dust sprays are much in use in the Middle West, although a great difference of opinion prevails as to their value. The result of the summer's work indicated a great superiority in liquid sprays, although some points investigated need confirmation, which is being obtained during the summer of 1909.

Demonstration spraying for the codling moth and apple diseases has been carried on in cooperation with the Bureau of Plant Industry in orchards in Arkansas, Virginia, Michigan, and western Missouri. The demonstration spraying in progress last season in southeastern Nebraska was successfully concluded, exact records being kept of the cost of the operations and the benefit in money as a result. A net gain of spraying of from \$2 to \$5 per tree resulted, and this is considered to be very favorable.

Further observations have been carried on in relation to the work of the codling moth in pears. Since the calyx lobes of pears do not close as they do with apples, certain differences in treatment are necessary, and spraying experiments have been carried on, at the request and in cooperation with pear growers in California, to determine the practical effect of these differences, and agents are also at the same time making life-history observations as possibly showing the necessity for differences in treatment.

THE GRAPE ROOT-WORM.

The work on the grape root-worm, begun in the spring of 1907, has been continued in the Erie grape belt, with headquarters at North East, Pa., in cooperation with the state department of agriculture of Pennsylvania. It has been shown to be practicable to protect young vineyards from further injury by a system of spraying and cultivation and also by the schedule of treatment which includes pruning, cultivation, spraying, and the use of fertilizers, to restore to excellent bearing condition old vineyards so badly injured by the root-worm as to become unprofitable.

ARSENIC ACCUMULATION IN SOILS IN SPRAYED WOODLANDS, ORCHARDS, AND VINEYARDS

The dying of orchard trees in certain portions of Colorado has recently been stated to result from the accumulation in the soil of arsenic following spraying, the arsenic becoming soluble and injurious to the trees by reason of alkali present in the water. The danger of similar injury under eastern conditions has, in consequence, been more or less agitated, especially in connection with the use of excessive strengths of arsenate of lead in the control of the brown-tail and gipsy moths. The question of danger of injury to orchard trees has also been raised. The importance of the matter warranted an immediate investigation, which has been undertaken in cooperation with the Bureau of Chemistry. Soil samples have been obtained and referred to the Bureau of Chemistry from woodlands in the vicinity of Boston, and from orchards in western New York, Illinois, Arkansas, and Virginia, and from vineyards in Erie County, Pa.

INSECTICIDE INVESTIGATIONS.

The increasing use of self-boiled lime-sulphur wash as a fungicide in place of Bordeaux mixture, especially on apple, has called for information as to the safety to foliage and efficiency of arsenicals when added to this preparation to effect a combination treatment for insects and diseases, as has been done for many years in the case of arsenicals and Bordeaux mixture. In cooperation with the Bureau of Plant Industry, numerous experiments have been made by adding to the self-boiled and commercial sulphur washes both arsenate of lead and Paris green in the usual quantities for orchard work. The tests made and in progress during the season of 1909 indicate that arsenate of lead may be safely used in the self-boiled wash on apple, and that it is not more injurious to peach foliage or fruit than when applied alone. While important chemical changes undoubtedly take place upon the addition of the arsenate of lead to the wash, as shown by a decided change in color, no injurious by-products apparently are formed. In the case of commercial sulphur solutions some injury has been noted. Also injury to foliage has resulted where Paris green was employed, though perhaps not more so than when this arsenical was used alone. In the course of these tests the self-boiled wash has been found to be very destructive to plant-lice infesting the apple and other plants, and equal in effectiveness to other insecticides commonly used against this class of insects. The tests with self-boiled lime-sulphur wash as a summer treatment for

the San Jose scale mentioned in my last report showed that even very badly infested trees could be largely freed from the insects by the two or three necessary sprayings employed in controlling fungous diseases. It therefore seems probable that, in addition to being an excellent and safe fungicide, as has been shown by the Bureau of Plant Industry, when so used on trees in foliage it will at the same time control scale insects and plant-lice, and by the addition of arsenate of lead will also act to control fruit and leaf feeding insects. The range of usefulness of this wash as a fungicide and insecticide clearly indicates that it will at once come into extended use.

FRUIT-TREE BARKBEETLES.

The investigation of fruit-tree barkbeetles in cooperation with the Ohio Agricultural Experiment Station, with headquarters at Lakeside, Ohio, was continued to the close of the growing season of 1908, and a preliminary report (Part IX of Bul. 68) was issued. The authorities of the Ohio Agricultural Experiment Station, while desirous of continuing the cooperative agreement for the season of 1910, were at the same time in position to carry out the work unaided by the Bureau, and consequently this work was closed, so far as the Bureau is concerned.

CEREAL AND FORAGE-PLANT INSECT INVESTIGATIONS.

As during the last year, the work of the section of cereal and forage-plant insect investigations of the Bureau, in charge of Mr. F. M. Webster, has been devoted largely to the so-called "green bug," the jointworms, and the Hessian fly, but new subjects demanding investigation have arisen, and the past fiscal year has been one of hard work and good results.

THE SO-CALLED "GREEN BUG" AND ITS PARASITES.

The so-called "green bug" was so greatly reduced in numbers by its natural enemies in 1907 that it was practically absent from most of its range until the late summer and early autumn of 1908. Its native food plants have been studied and twenty-five species have been found, on many of which it can feed as on grain, these constituting alternative food plants. The life history of the species has been followed continuously through two years, and the conditions have been ascertained which facilitate its increase with the greatest rapidity. A number of new parasites have been found and the habits of the principal species have been studied with great care, and the knowledge has been gained of just when and under what conditions these parasites can be depended upon to prevent an invasion of the green bug and what the farmer must do himself to ward off or reduce the severity of the invasion. The temperature of the winter of 1908-9 was favorable for the development of the pest, and the abnormally low temperature in the spring of 1909 gave the insect a chance to increase in numbers, so that during the late spring there were local injuries in western North Carolina, northern Georgia, southern Oklahoma, and southeastern New Mexico. The investigations of these local outbreaks have shown that the farmer can do much to protect himself by preventing the growth of volunteer grain in fields

intended for fall wheat or oats and by delaying the sowing of these crops as late in fall as possible. The object is to prevent the pest from becoming established in the fields until a late date in the fall. This reduces the period during which the growing grain may be attacked and prevents the increase of the green bug to the destructive point before its natural enemies arrest it in the spring. Should the pest, however, become established in the field early in the autumn its work will first be observed in spots, and these spots can be treated effectually by kerosene emulsion or by the whale-oil soap mixture, or they can be plowed under and the surface of the ground rolled, or straw can be scattered over the spots and burned.

It seems unlikely that the farmer himself will be able to determine whether his crop is threatened. The insect is so minute, so secluded in its habits, and resembles other plant-lice so much that it requires competent entomologists to constantly watch the status. This should be done by employees of the Bureau and of the different States involved, in cooperation.

WORK ON JOINTWORMS.

Careful studies in the Northwest of damage by the wheat straw-worm have indicated that damage from its ravages can be prevented by cultural methods. Its injury is induced by growing crops of winter wheat repeatedly upon the same land; by leaving volunteer plants among the spring wheat; by allowing the summer fallow to grow foul with volunteer wheat, even at a distance from wheat fields, and by growing spring wheat near winter wheat. The remedy lies in avoiding these conditions by rotation of crops, clean early summer fallow, and the abandonment of spring-wheat culture in infested regions.

A serious outbreak of the true joint-worm in Ohio, Indiana, and Illinois has occurred. Information is accumulating which goes to show that late seeding of wheat in connection with rotation of crops tends to reduce its injuries.

HESSIAN FLY INVESTIGATIONS.

In 1908 there was an outbreak of the Hessian fly in southern Kansas, which was so severe that many fields were left unharvested. Fortunately, three series of wheat-sowing experiments had been established by the Bureau in the fall of 1907 in Kansas, and two of these were within the area of severest destruction by the fly in 1908. In this way the Bureau had exact data to work upon both preceding and during the outbreak. The immunity of wheat sown after certain dates in the fall of 1907 was so apparent that a campaign of late sowing, based on these results, was instituted and followed up by the experiment station, the agricultural press, the millers, the grain dealers, and, in one instance, by a church organization. As a result the crop of 1909 practically escaped attack, the parasites, and particularly the species introduced by the Bureau from Pennsylvania, having apparently overcome the pest in those instances where its numbers were increased by volunteer and early sown wheat. At the prevailing price of wheat during 1908 and 1909 it is a safe estimate that the wheat-sowing experiments in Kansas resulted in the saving of \$500,000 or more. The investigations on this insect will be continued, and will include work in transporting parasites and establishing them on the Pacific Coast and elsewhere.

OTHER INVESTIGATIONS.

The slender seed-corn ground-beetle has been studied for two years. Under-drainage, rotation of crops, and late planting have been found to afford almost perfect control of the pest.

The investigations on the southern corn root-worm have been continued with gratifying results, and practical preventive measures seem to be in sight.

The southern corn leaf-beetle is being studied by an agent, and careful investigations are being made of the sorghum seed midge, since planters of the South are unable to grow sorghum seed on account of the ravages of this insect.

A most unusual and serious state of affairs has been found to exist in northeastern New Mexico, where the larva of a large moth of the genus *Hemileuca* has been attacking the grama grass on the cattle ranges in increasing numbers and over continually widening areas. Hundreds of acres were ravaged last year, leaving the ground as bare as if it had been burned over. In October and early November the moths swarmed over the country miles from their place of origin and deposited their eggs in millions. The pest bids fair to render many square miles of range absolutely worthless for grazing. These insects are being carefully investigated by the Bureau.

Other insects now being studied are the corn root-aphis, the cowpea curculio, a new wheat enemy in New Mexico of the genus *Meromyza*, alfalfa insects, a corn leaf-miner, clover insects on the Pacific Coast, grasshopper outbreaks and their control, and other outbreaks.

WORK ON INSECTS INJURIOUS TO VEGETABLE CROPS.

The widened scope of work on insects injurious to vegetable crops, under the direction of Dr. F. H. Chittenden, has made possible more satisfactory results than heretofore. The reasons for the establishment of stations to study these insects were given in the last annual report.

INVESTIGATIONS IN TIDEWATER VIRGINIA.

The Bureau was continuously at work in 1908 in cooperation with the Virginia Truck Experiment Station and a produce company of Norfolk, Va., upon the insects damaging the truck crops of that region, the total value of which is estimated to amount to \$15,000,000. The principal insects studied were spinach and cabbage plant-lice, the Colorado potato beetle, the striped cucumber beetle, the onion thrips, the bean leaf-beetle, the pea aphid, the cabbage webworm, and some others. Field work on a large scale with different remedies was carried out, and it was demonstrated that with the majority of these species control is easy and economical.

WORK IN SOUTHERN TEXAS.

The same class of work has been carried on in southern Texas as in previous years. The insects under special investigation have been the melon aphid, the onion thrips, some beetles closely related to the northern cucumber beetles, corn root-worms, certain forms of beetles

injurious to potato, several flea-beetles, including a new enemy of beets, the southern cabbage butterfly, and certain species of leaf-hoppers, and a number of injurious caterpillars, including the imported cabbage webworm. Extensive work has been done on a number of these species, many of which have not been previously investigated.

The insect enemies and parasites of a number of species of plant-lice have been studied, and there is some promise of interchange of species of beneficial parasitic and predaceous insects to act as destroyers of the melon aphid.

WORK IN FLORIDA.

The principal subject of investigation in Florida has been the tomato fruit-worm, or corn earworm, with especial reference to its control on tomato. It was ascertained that the most successful means of fighting injury by this insect is to plant early and also to make several successive plantings of corn in the tomato fields, so that in the last five weeks of the growing season there will be a supply of corn silk to attract the moths to lay their eggs. This draws them from the tomato and is a practical point of some importance.

The pickle and melon worms were also studied, and work on their life histories was completed. For the melon worm, arsenate of lead has been found to be the best method of control. This is sprayed upon the foliage for the earlier generations, and is not dangerous to melon eaters.

OTHER WORK.

Further investigations have been made in the principal sugar-beet regions in southern California, where two species of plant-lice affecting the beet roots, the beet leaf-miner, certain flea-beetles, and other insects are doing considerable damage.

In addition to these distinct pieces of work, a general survey of truck-crop insects the country over has been kept up, and studies have been made of numbers of the most important species.

An interesting development of the year has been the finding of a parasite of the eggs of asparagus beetles in New England. This parasite on one farm developed to such an extent as to render the employment of artificial remedies unnecessary, resulting in the saving to this farm of about \$200, which would otherwise have been expended in insecticides and labor. This parasite is under investigation by the Massachusetts experiment station and by the Bureau with a view to its possible introduction into other localities.

WORK ON INSECTS AFFECTING CITRUS FRUITS.

Work on insects affecting citrus fruits has been carried on during the year under the direct supervision of Mr. C. L. Marlatt. The principal items have been a continuance of the white-fly investigations, work on the hydrocyanic-acid gas fumigation in California, and work upon the orange thrips, also in California.

WORK ON THE WHITE FLY.

The investigation of the white fly in Florida has been continued with the view of placing every practicable line of control on the best possible basis. The decrease in profits from citrus culture in Florida during the last two years has emphasized the necessity for a most exhaustive study of all phases of the subject, so that advantage may be taken of every factor which may aid in reducing the expense of control to a minimum. During the fiscal year ending June 30, 1909, life-history studies and fumigation experiments were practically concluded, experiments with contact insecticides were taken up again after having been discontinued temporarily to allow the conclusion of the more important fumigation experiments, experiments with the fungous parasites were continued with much progress in determining their degree of usefulness, and the study of trap foods has been taken up as a new project.

It proved desirable to carry certain lines of life-history studies of the citrus white fly through another year in order to cover a wider range of conditions. The discovery of the existence of another injurious species of white fly on citrus trees in Florida has made necessary a comparative study of its life history, economic importance, and control. Fortunately, this second species is of limited distribution, has no other known food plants than citrus, and is more easily controlled. It has been found that where it occurs in the same tangerine or orange grove with the citrus white fly (*Aleyrodes citri* R. & H.) it assumes a position of relative insignificance.

Fumigation experiments were conducted on a large scale in cooperation with several orange growers. The main object has been to determine to what extent this process may be used, without regard to the white-fly situation in neighboring groves, by citrus growers whose groves are not isolated. In addition, extensive experiments have been conducted in fumigating nursery trees, which will be of great value to nurserymen and to orange growers with newly planted groves. The new process of estimating the dosage referred to in the last report has been used by previously inexperienced citrus growers with success, as was predicted. This process, consisting of a specially marked tent for use in connection with a new form of dosage table adaptable for use against any insect, has been introduced into California and made the basis of an improvement in the old system of fumigation in that State.

An extensive series of experiments has been conducted to determine the efficiency, cost, and the effect on citrus foliage of each of the many contact insecticides in use against the white fly. The time required for work in progress in other lines did not permit the completion of all spraying experiments as planned. There remains for completion a thorough study of the methods of application. The type of spray nozzle, its discharge capacity, pressure required for best results, and amount of spray per tree are the important points in this connection.

The experiments with the fungous parasites have resulted in acquiring very extensive data which appear to lead to the conclusion that has been arrived at in connection with fungous diseases of the chinch bug, i. e., that the successful development and spread of the fungous growths are too dependent upon weather conditions for

reliance to be placed upon them, even with the best methods of artificial dissemination of the spores. There is a great deal of misinformation current among Florida citrus growers in regard to the efficacy of the fungous parasites, requiring conclusions in this line to be supported by data of the most convincing kind. One species of fungus which has been considered by other investigators as a parasite of the white fly has been proved to be principally saprophytic, rarely, if ever, developing on living insects. It is expected that final conclusions in regard to the known species of fungous parasites of the white fly will be reached by the end of the calendar year.

The investigation of the usefulness of trap foods includes practical field experiments in the pruning of citrus water-shoots at advantageous times and studies of the attractiveness to adult citrus white flies of various non fruit-producing food plants. The pruning of water-shoots has been found to be a very important factor in the control of *Aleyrodes nubifera* under some conditions, and the work now in progress aims to show the limits of its usefulness. The citrus white fly, on the other hand, is not so greatly affected by the removal of water-shoots, but its attraction to china and umbrella trees, as compared with citrus trees, during the time of flight of the first two broods, is such that the possibility of utilizing these trees as trap foods requires investigation. Preliminary studies in this line have been made, but extensive field experiments can not be undertaken before the spring of 1910.

The agent in field charge has been of practical service to many citrus growers from all sections of the State who have visited the laboratory at Orlando for advice and to many others who have asked for advice through correspondence. In this way much has been accomplished in furthering cooperative control measures against the white fly, particularly in sections newly infested.

INVESTIGATION OF HYDROCYANIC-ACID GAS FUMIGATION IN CALIFORNIA.

The work on hydrocyanic-acid gas fumigation in California, taken up at the beginning of the fiscal year ending June 30, 1908, was reported upon in a preliminary way in the last annual report, and the reasons for the investigation were there given. The work has continued along strictly economic lines, with the primary object of increasing the efficiency of fumigation, as well as decreasing its cost. The progress has been satisfactory. A large amount of new and useful information has been secured which, put into practice with the improved methods, has already practically revolutionized the old wasteful procedure which possessed none of the elements of uniformity. Much of this information has been incorporated in Bulletin 79 of the Bureau.

An important system of fumigation, which is both practical and scientific, has been introduced, and is rapidly leading toward standardization of the entire practice. Within three months after its announcement to the public more than a dozen practical outfits had adopted the methods, while at present it would seem to be a fair estimate that before the next season closes practically all of the fumigating outfits in southern California will be working under the standard system devised by the Bureau. Results from the use of this system on several hundreds of acres of citrus groves have demonstrated a striking superiority over those gained previously, while it seems

quite probable that after the general adoption of the system a single treatment every second year will accomplish the same results as an annual treatment, giving an annual saving of from 30 to 50 per cent of the present cost.

By the experimental treatment of several thousand trees under varying conditions the most economical dosage to be used against the purple scale and the red scale, the most injurious of the enemies of citrus trees in California, has been determined. These experiments have also covered the effects on the results secured of different periods of exposure of the insects to the gas. Exposure of one hour appears to be most effective against the purple scale, while for the red scale the time may be reduced to forty-five minutes.

A number of small practical points have been brought out, including the devising of a new cover for vessels which prevents the burning of tents and allows for the better distribution of the gas. The material used for making the tents has also been looked into, and a number of cloths very superior to those in present use have been found.

In important practical results the investigation has been one of the most satisfactory carried on by the Bureau of late.

THE ORANGE THRIPS.

A new insect enemy of the orange has become prominent in the San Joaquin groves of California, the groves of Portersville and Lindsay, and adjacent territory in Tulare County. This is an important and rapidly developing orange district, and extends along the western border of the Sierra foothills from a point east of Fresno to a point south of Portersville. The orange thrips has been present for some years, but recently its injuries have become so extensive as to attract general attention. It punctures the rind of the newly set fruit and of the older fruit, bringing about the scabby or russet condition and reducing the market value of the fruit. The tender foliage is also seriously injured, especially the foliage of nursery stock.

The investigation of this insect, although it affects citrus fruits, was assigned to the section of deciduous fruit insects, on account of its relationship to the pear thrips under investigation in the same State. A special agent was assigned to the problem in April, 1909, and is giving special attention to methods of control as based upon experience with the pear thrips, and at the same time is carrying on a detailed study of the life history and habits of the insect.

A combination of tobacco extract and distillate oil spray, which proved so effective with the pear thrips, will also kill the orange thrips, but it seems evident that a considerable number of applications will be necessary to protect the orange crop, on account of the continued breeding of the pest, which obviously has several generations and no long resting period, in contrast to the pear thrips.

INVESTIGATIONS OF INSECTS IN THEIR DIRECT RELATION TO THE HEALTH OF MAN AND DOMESTIC ANIMALS.

In the course of the investigations of insects in their direct relation to the health of man and domestic animals, mosquitoes have been actively studied as during the past decade, and new points of practical value have been brought out. It has been discovered that a

large part of the mosquito supply of otherwise well-conditioned sections of large cities is sewer bred, and that the malaria-bearing mosquitoes in dry summers will breed in sewer traps, making it extremely important for the health officials to treat all sewer traps with kerosene or some other culicide.

WORK ON THE HOUSE FLY.

The work on the house fly has been continued, and a bulletin upon this insect and other disease-bearing insects has been published which has attracted still further attention to this unnecessarily dangerous pest. The crusade against the house fly indicated in the last annual report has become, during the past fiscal year, of almost a national character. So many boards of health have taken it up and so many civic organizations have concentrated upon this subject that the whole country may fairly be said to have been aroused. The writer has suggested in a recent publication that an effort be made to change the popular name of the house fly to the typhoid fly, with the idea that should people at large begin to think of it as a disease bearer they would no longer suffer its presence in the house and on their food with the same equanimity as in the past.

WORK ON THE TEXAS CATTLE TICK.

Substantial progress was made in the experimental work on the tick (*Margaropus annulatus* Say) which transmits splenic fever of cattle. This work was conducted by Mr. W. D. Hunter and Mr. F. C. Bishopp. The observations on the habits and life history were in general in continuation of the work that was under way during the preceding fiscal year. Special attention was devoted to the determination of the points in life history that are of importance in the various systems of control involving the transference of the cattle from one pasture to another. This work is of great importance to ranchmen in the area that can not naturally be reached for some time in the plan of total eradication that is being successfully conducted by the Bureau of Animal Industry. Recent agitation has called the attention of cattle owners everywhere to the importance of reducing the number of ticks where the plan of total eradication can not be applied at this time. This has caused a demand for information that the Bureau's work supplies.

Considerable attention was paid to obtaining data regarding the developmental periods of the fever tick in different localities. Work done in one place will not necessarily apply elsewhere. For this reason cooperative experiments were conducted with the Tennessee and Arkansas stations and two experimental localities were utilized in Texas.

In addition to the foregoing work, which is the basis of any control measures that can be put into operation, the Bureau of Entomology conducted several practical demonstrations of the methods of reducing injury. The demonstration in Victoria County, in which an area of a square mile was used for the purpose of cleaning cattle of ticks, was repeated. Another experiment was carried on on a pasture in Calhoun County. In addition to this work, which has been done under formal agreements with the Bureau of Entomology,

a number of ranchmen have taken up the work. Mr. J. D. Mitchell, of the Bureau, has assisted ranchmen in instituting work of this kind in connection with his experimental work.

Tests were made of the possibility of the carriage of fever ticks by animals other than cattle, horses, and sheep. It is highly important to know to what extent other animals may carry the fever species because the occurrence of a comparatively small number of ticks on some other host would nullify all of the work in eradication. It is therefore necessary to obtain very full information. Exceptional cases of various animals serving as hosts must be investigated with care.

In connection with the main work of the Bureau on the various species, attention has been directed to other forms that occur in the South. Several of these, like the lone star tick (*Amblyomma americanum* L.), and the Gulf coast tick (*Amblyomma maculatum* Koch) are of considerable importance as parasites. Man, as well as many domestic animals, is affected by them. Moreover, some of them may eventually be found to be concerned in the transmission of diseases. For these reasons, as time permitted, studies of life histories and habits were conducted.

Some attention was devoted to the study of the fowl tick (*Argas miniatus* Koch) in Texas. In several parts of the world this tick has been found to be the agent in the dissemination of a very serious disease of fowls. In Texas this disease has not been found to occur, but the tick causes very serious injury merely as a parasite. In certain districts the profitable raising of poultry has been rendered impossible. An investigation of this tick has indicated feasible means of control that should enable farmers to reestablish the poultry industry where, in some cases, it has been abandoned.

There is another species, the spinose ear tick (*Ornithodoros megnini* Dugès), which is of importance in the western portion of Texas. This species lodges itself in the ears of cattle and horses and not infrequently causes death, especially in the cases of young animals. While no special experiments could be conducted, observations regarding the extent of damage and the possible means of control were made in connection with the other work. This tick is of sufficient importance to justify special investigation.

A parasite of a tick (*Rhipicephalus texanus* Banks) closely related to the fever-transmitting species was found in southwestern Texas. Experiments were instituted to cause this parasite to attack the cattle tick, but up to this time without success. The parasite is very common in the region of Corpus Christi, Tex., and has an important effect in checking its host, which occurs on the dog. The attempt to cause the species to attack the cattle tick is of especial interest.

A limited amount of work was done on the tick which transmits the so-called spotted fever of human beings.

WORK ON INSECTS INJURIOUS TO STORED PRODUCTS.

Work on insects injurious to stored products, under the direction of Dr. F. H. Chittenden, has been carried on in the directions indicated in the last report.

In continuation of the investigations begun in 1908 at the request of many milling companies in Kansas, Oklahoma, Missouri, and

Texas, and of steamship owners and operators in Texas and Louisiana, much work has been done. Especial attention has been given to the flour beetles and to the determination of the place or places at which export flour from the different States mentioned becomes infested, whether chiefly at the mills or at Galveston, or at New Orleans, or on the cars, steamships, or wagons used in carting the material from the mills to the carrier. There is no doubt that infestation occurs at all of these points, but it is feared that in some cases primary infestation begins at the milling establishments, although some of the mills which have been investigated are kept scrupulously neat and are thoroughly fumigated at least twice yearly.

The insect which has recently engaged the most attention is the Mediterranean flour moth, which seems to be the most destructive mill pest in the world. It was first recognized in this country in 1892, and has since been reported from almost every important milling section of the United States. Investigations by the Bureau seem to indicate that fumigation of milling establishments with hydrocyanic-acid gas is the most perfect method. Bisulphid of carbon is less effective as a rule, and the same may be said of fumigation with sulphur dioxid. It seems possible to stamp this species out with the cooperation of all the milling establishments concerned in any given locality. Experiments indicate that the insects can be destroyed in a badly infested building with two fumigations at the rate of 8 ounces of cyanide of potassium to 1,000 cubic feet of space, provided the buildings have been tightly closed. The economic importance of this pest is indicated by the fact that one miller has stated it has cost him \$5,000; another one that it costs \$2,000 per year for fumigation.

Several stored-product insects have attracted much attention during the year. These are the granary and rice weevils, the Angoumois grain moth, and the flour beetles. Some new habits of these insects have been discovered, and the experiences of practical grain dealers and millers are being collected, with a view to the publication of a full report on insects affecting stored cereals.

INSPECTION WORK.

As in previous years, the plant material introduced by the Bureau of Plant Industry has been inspected at the Department greenhouses for dangerous insect pests and has been fumigated wherever necessary. Special attention during the past year has been paid to the fumigation of all mango stock on account of the presence of two new Indian scale insects. During the course of the year 1,710 certificates of inspection were granted. Since the regulation of the express companies requires a certificate of inspection to accompany any plant material for shipment, and since there is no official nursery inspector for the District of Columbia, this general inspection work has fallen upon this Bureau. One hundred and four certificates were granted for trees and plants shipped from the District of Columbia, and 2,495 lots of plants imported by the Division of Seed and Plant Introduction of the Bureau of Plant Industry have been inspected for insect pests. Besides numerous cosmopolitan pests, several apparently new species of insects were found and killed.

INSPECTION OF TEA FARM.

During March, 1909, Doctor Shepard, the owner of the tea farm at Summerville, S. C., sent specimens of tea leaves infested with scale insects which were threatening to destroy the plantation. An expert was sent to the farm and found five dangerous scale insects of Asiatic origin infesting the tea plants and neighboring camellias. Since all the tea plants were grown from seed, the method of introduction of these scales was unknown until it was found that large numbers of Japanese camellias had been introduced and planted near the tea plants.

INSPECTION FOR BROWN-TAIL MOTH.

In January, 1909, the Bureau was advised by the commissioner of agriculture of the State of New York that the brown-tail moth had been found in shipments of seedlings from Angers, France. Later advices from Ohio indicated that the winter nests of the brown-tail moth had been found upon seedlings imported from the same locality. Warning letters were sent to different state entomologists; the customs officers at the different ports of entry were notified by the Secretary of the Treasury to inform the U. S. Department of Agriculture immediately upon the arrival of any nursery stock from abroad; the principal railroads were notified of the danger of carrying such plants, and their attention was called to the law of March 3, 1905, providing that no transportation company shall knowingly carry plants infested by injurious insects, under a penalty of a fine of not more than \$5,000, or imprisonment at hard labor for more than five years, or both. As a result, not only customs officers but the railroads promptly notified the Bureau at Washington of the ultimate addresses of all cases of plants received, and in this way the Bureau was enabled to notify state inspectors and other competent persons near the points of ultimate destination of such packages, and inspection was thus brought about in all probability in all instances where plants were received after January, and probably also before that date, since information was received from the customs officers of the destinations of the early winter and late autumn receipts. The Bureau was in this way enabled to send notifications of nearly 800 shipments, divided among 35 different States. In fifteen of these States, namely, Alabama, Georgia, Illinois, Iowa, Kansas, Kentucky, Maryland, Massachusetts, Missouri, Nebraska, New Jersey, New York, North Carolina, Ohio, and Pennsylvania, nests of the brown-tail moth were found, and in one locality in Ohio a single broken egg-mass of the gipsy moth was found. Prof. P. J. Parrott, of the New York State Agricultural Experiment Station at Geneva, N. Y., has found in his summer's inspection that still another European fruit-tree pest (*Hyponomeuta padella*) has been introduced, probably on these French seedlings.

NECESSITY FOR A NATIONAL QUARANTINE AND INSPECTION LAW.

This concerted effort to destroy all these imported insect pests was probably successful, but the danger of such shipments was emphasized in a more striking manner than ever before. The United States is practically the only one of the great nations of the world

which has not protected itself from such accidental importations of pests of this character by a national quarantine and inspection law. Such laws have been introduced before Congress in previous years, but have failed of passage. Toward the close of the last session of Congress a national quarantine and inspection bill was drafted and sent to Congress by the Secretary of Agriculture. It passed the House of Representatives, but failed to pass the Senate. The bill as introduced was not satisfactory to the legislative committee of the American Nurserymen's Association, but it is hoped that a measure more satisfactory to them may be introduced at a later date and that the whole country will receive protection through its operations.

In June, 1909, the Chief of the Bureau visited Holland, France, and England for the purpose of looking into the European methods of growing nursery stock for the American market and of investigating the nursery-inspection systems in those countries, which are the greatest exporters to America. He found that the inspection system of the Government of Holland under the direction of Prof. J. Ritsema Bos, director of the pathological station of Wageningen, is admirable. All of the Dutch nurseries are carefully inspected twice each year. The nurserymen are well educated on the subject of remedies. The Ritsema Bos inspection certificate can be relied upon.

In France it was found that there is no governmental inspection system of nurseries. The certificates attached to shipments of nursery stock received in this country coming from France are signed, as a rule, by men connected with the agricultural schools, and, as last winter's experience has shown, are not reliable. Nursery stock for export is, in many cases, grown in the vicinity of hedges and trees infested by brown-tail moths, by the gipsy moth, and by other injurious insects as yet not introduced into the United States, and down to the present time there seem to have been no special precautions taken by the nurserymen to prevent the infestation of their stock by injurious insects. It seems reasonably sure that the infested nursery stock imported last winter into the United States came from such regions as have just been described. In the late June and July flight of the adult brown-tail moths coming from hedges or woods adjoining nursery plantations many of these moths must have laid eggs upon the young nursery stock in the vicinity. These eggs hatched in August, the very small young larvæ fed somewhat upon the leaves, webbed up into their characteristic winter nests, and were sent with the seedlings to America. The nests are noticeable, and only extreme carelessness, indifference, or ignorance on the part of the French exporters could have allowed them to be packed without removal. The French exporters now promise to take all possible precautions, and the French minister of agriculture has promised to found a competent governmental nursery inspection service under the direction of Dr. Paul Marchal, a most learned and competent man, and to thus guarantee the freedom from pests of nursery stock shipped to the United States in the future.

In England, as in France, there is no governmental nursery inspection. Conditions in the nurseries are somewhat better than they are in France, but the brown-tail moth occurs in England, and other very injurious insects which may easily be imported upon nursery stock.

Officials of the government board of agriculture, in London, stated that the Government had had the establishment of an inspection service under consideration, and was perfectly willing to institute such a service, but that the demand must come from the British nurserymen themselves. Therefore, prominent members of the National Horticultural Trades Association of Great Britain and Ireland were interviewed, and the near establishment of a competent inspection service under the board of agriculture seems probable.

INTERSTATE INSPECTION.

During the fiscal year 1909 the file of the state nursery and orchard inspection laws has been made complete by continued correspondence with the state inspectors in charge, and a revised circular has been issued, giving the requirements for shipping nursery stock into the different States, for the benefit of people engaged in this industry. It is necessary to devote considerable attention to this matter, as new laws are being enacted almost every year and new regulations are continually being made by the inspectors or official boards in charge of the work. An effort has been made to secure data concerning the cost of inspecting nurseries in the United States, the amount appropriated to carry on this work, and the work of orchard inspection as well. A statement of the number of orchards annually inspected has been compiled, with the views of the different inspectors concerning the efficiency of the work under state supervision as it is now being conducted. This information should be of considerable value as forming a good basis for a general law bearing on the inspection of importations from foreign countries.

WORK IN BEE CULTURE.

The work in bee culture has been carried on, as before, under the direction of Dr. E. F. Phillips, and covers practically the same projects as in the previous year.

WORK ON BEE DISEASES.

The main line of work carried on this year was, as in former years, an investigation of the brood diseases of the honey bee. The study of the micro-organisms that cause disease or are found in diseased material has been continued. As was stated in the last annual report, the cause of American foul brood was determined in the investigations of this office, and during the year a further study of this organism has been made. The cause of European foul brood is not yet fully established, but a study of one organism (temporarily named "Bacillus Y") now under investigation promises favorable results as soon as more suitable culture media can be obtained for its cultivation. Extensive experiments on the amount of heat and chemical disinfectants necessary to kill the spores of *Bacillus larvæ*, the cause of American foul brood, have been begun during the year. These results are highly important in determining the methods of disinfection to be used in treating an infected apiary.

Work on the distribution of the different brood diseases was taken up on a more extensive scale at the beginning of the season of 1909,

and samples are now being received from all parts of the country. The material for this work was obtained by sending out circulars to correspondents of the office and by advertisements in bee journals. During the past year 280 samples were received and examined, of which 180 were obtained during June. This taxes the capacity of the present bacteriological laboratory. The information gained from this work has already been of great value, especially in giving information to state legislatures which are contemplating the passage of laws providing for the much-needed inspection of apiaries. At the close of the present season all of the available data will be arranged geographically for publication. This is the first extensive attempt at a study of the distribution of bee diseases in this country. Circulars giving symptoms and treatment of the various bee diseases are sent out to all bee keepers whose names can be obtained in regions from which samples are received, and every effort is made to aid the bee keepers in getting the diseases under control. The practical value of this work is perhaps greater than that of any other line of work now being attempted, nor is there any aid more needed. It was found that European foul brood has recently appeared in the San Joaquin Valley in California and in western Mississippi, causing considerable damage. In these cases special circulars were sent out to bee keepers in the regions especially in danger. The work on distribution is showing the presence of disease in many localities previously unreported, and indicates even greater losses from this source than have been recognized in the past.

During the past winter a large paper was almost completed reviewing all the work that has been done on the cause of infectious diseases. This will help greatly in clearing up the confusion still existing in the minds of many bee keepers as to the nature and extent of the work which has been done by the various investigators who have worked on this subject.

The work on new and better methods of treatment which was begun on a large scale during the fiscal year 1907-8 was continued the past fiscal year, as far as the apiary facilities would allow, with very valuable results. This work is being continued during the present season, the object being to get less expensive methods. This work will require considerable time and labor.

During the past year the bee keepers of several States have been active in attempting to get laws enacted providing for inspection of apiaries. Satisfactory laws of this kind were passed in South Dakota, Indiana, and Iowa, and proper regulations were made in Hawaii. The proposed bills failed of passage in Pennsylvania, New Jersey, Massachusetts, Connecticut, and Illinois. The proposed revisions of previously enacted laws in California and Texas also failed. The chief reasons for failure in these cases is that but few bee keepers go before the legislatures and those who do go are not provided with sufficient data as to the distribution of the diseases and losses resulting from them. This office helped in the drafting of several of the proposed bills, and aims to aid in every legitimate manner by furnishing information as to the distribution of diseases and the losses resulting therefrom.

STUDIES OF THE STRUCTURE AND DEVELOPMENT OF THE BEE.

Work on almost all other lines of apicultural investigation has shown the very urgent need of a careful and detailed study of the structure and development of the bee. The knowledge of the average bee keeper concerning the animals with which he works is much less than that of men engaged in almost any other line of animal industry. Without knowledge of this character it is very difficult, if not impossible, to make proper progress in a study of the pathology of bee diseases, queen rearing, behavior and activity of the bee, and many other important lines of investigation. The work done by other investigators has been shown, in the main, to be either very inaccurate or incomplete and, to supply these wants, investigations in these two fields were carried on during the past year. Such work will not only add greatly to our knowledge of the bee, but will unquestionably be of great value in devising and correcting practical manipulations. It can scarcely be expected that the average bee keeper will show much interest in such work, but the practical results of such investigations will prove of great value to investigators and of interest to all progressive bee keepers.

WAX ANALYSIS.

During the past year a beginning was made in collecting samples of beeswax from all parts of the United States for analysis and study. These samples are to be turned over to the Bureau of Chemistry for analysis, and tests will also be made of the bleaching properties and in other ways to determine the relative commercial value of the various waxes. It is hoped to prepare for beeswax a mass of material comparable to what has been done for American honeys, as reported last year. Some work was done on methods of wax extraction.

THE ACTIVITY OF BEES.

The work on the daily activity of a colony, mentioned last year, has been brought to a close, and results will be prepared for publication soon. Some investigations were made as to the methods of gathering propolis and the sources from which it is gathered. This has been a much debated question among bee keepers since Huber's time.

The basis for intelligent practical manipulation rests almost entirely on a knowledge of bee behavior. The literature on this subject is very scattered and there is no single available English publication which can be relied on fully. A general review of this subject with some new observations has been begun during the past year and will be completed as soon as possible.

STUDY OF THE STATUS OF BEE KEEPING.

During the past year a publication (Bul. 75, Part VI) was issued giving a summary of the best available information concerning the present conditions of the bee-keeping industry in the United States. Another publication (Bul. 75, Part V) of the year was a report on bee keeping in Hawaii, this being an account of the trip to Hawaii mentioned in the last annual report. As supplementary to this, a paper was issued by the Hawaii Agricultural Experiment Station

on Hawaiian honeys. The detailed study of bee keeping in Massachusetts, mentioned last year, is completed and the results have been published. (Bul. 75, Part VII.)

Detailed studies of bee-keeping conditions have proved so valuable that similar work is being carried on in Maryland, Pennsylvania, and parts of Virginia. By getting in direct touch with bee keepers it is possible to locate many new outbreaks of disease and to help in various other ways. It is also a great help in getting our publications into the hands of bee keepers. It is hoped to enlarge the scope of this work as rapidly as possible.

UNCLASSIFIED WORK.

Much work has been carried on during the fiscal year which can not be classified under the main topics already considered.

INSECTS INJURIOUS TO THE PECAN.

Investigations of insects injurious to the pecan, made in earlier years and carried on with a fair degree of success by means of special correspondents, and later by the help of a special agent, have been continued. An agent has been stationed in Florida, taking occasional trips into South Carolina. The principal insect under investigation has been the pecan bud moth, which seems to be the most injurious enemy of the pecan tree. Its life history has been under especial study. Similar life-history studies have been made upon another bud moth, upon a leaf miner, and upon certain forms of borers. A preliminary report will soon be put into shape.

INSECTS INJURIOUS TO SHADE TREES AND ORNAMENTAL PLANTS.

There is great demand for information in regard to insects injurious to shade and ornamental trees, and an effort is constantly being made to bring the published information to date. The facilities for extensive experiments, however, are slight. Circulars and Farmers' Bulletins containing information in regard to some of the principal pests, such as the tussock moth, fall webworm, imported elm leaf-beetle, bagworm, green striped maple-worm, red spider, the rose slugs, and the leopard moth, as well as the cottony maple scale, have been published.

A large amount of time is taken up in correspondence on this class of pests each year.

WORK ON SCALE INSECTS.

During the year a large amount of scale-insect material has been received from different parts of the world and carefully studied by experts. It is most important that the Bureau should be thoroughly informed on the scale insects, not only of this country but of all parts of the world, since there is no group of insects so liable of introduction from one country to another as this group. A second supplementary list of recently described scale insects, with full bibliography, has been prepared for publication.

OTHER WORK.

An elaborate attempt has been carried on to systematize all the notes and records of the Bureau and to verify the determinations of practically all specimens referred to in the notes. A large number of biological records have been made of species hitherto unstudied in the Bureau.

Work on the part of specialists in the Bureau, referred to in previous reports, in the determination of specimens sent in by state entomologists and other workers in practical entomology, has increased. A close estimate of the number of specimens named in this way during the fiscal year reaches the very large total of 23,000. The correspondence of the Bureau continues to increase. During the fiscal year, in addition to answers to correspondence by circulars, nearly 19,000 letters have been written.

The publications of the Bureau during the year have reached 23 numbers.

PROPOSED WORK FOR THE FISCAL YEAR 1910.

At the present writing the work for the fiscal year 1910 is well under way and, in part, consists of a continuation of the lines just indicated.

With the gipsy moth and brown-tail moth very slight changes in methods and plans are being considered. Constant effort will be made to reduce the cost of the methods in use, and constant experimentation will be carried on, in the hope of finding some large wholesale manner of caring for woodland regions. Where property is of sufficient value or interest to the owners, the moth is handled without great difficulty, but the large tracts of low-priced woodlands, where the owners can not afford or are unwilling to spend any considerable sums of money, constitute the most serious problem in the course of the work.

It is planned to continue in the same way the importation of useful insects, especially the parasites of the gipsy moth and brown-tail moth, of the imported elm leaf-beetle, and of the codling moth.

With the Mexican cotton boll weevil the most important work is being conducted in Louisiana. Two years' experience in that State have convinced all careful observers that special means of control of the weevil must be devised to suit the peculiar conditions which exist in the Mississippi Valley. The methods that have been successful elsewhere have been tried, and have been found inadequate. The means utilized in Texas resulted from careful technical studies of the life history and habits of the weevil. Logically, therefore, since in the Mississippi Valley the conditions are so different, similar careful technical studies of the life history and habits of the weevil must be made there as the basis for remedial work. For these reasons the Bureau has established a laboratory at Tallulah, La., in a region typical of the Mississippi Delta country. All features of the life history of the weevil are being carefully investigated there, and field experiments with new lines of control have been instituted. This work will occupy the attention of three expert assistants resident in the delta. Especial attention will be paid to the increased effectiveness of parasites. This is the most hopeful aspect of the situation at present, but every possibility will be investigated with

care. As heretofore, the experimental field work, however, will be continued throughout the whole infested area. As far as practicable, the work will be reduced in Texas and increased in Louisiana. In the latter State field work is under way at eight places. Experiments with machinery for the control of the beetle will be continued. The status of the weevil will be determined from time to time, and estimates of damage will be made and field work in the determination of the extent of dispersion will be carried on for the benefit of States that have quarantines in operation, as well as for the information of planters, who must make the earliest possible preparation for the arrival of the pest. Moreover, attention will be paid to the discovery of isolated colonies, and if any should be discovered, energetic attempts will be made to stamp them out.

With regard to tobacco insects life-history studies will be continued, and demonstrations, through cooperative experiments as to the effect of poisons, with fall plowing and other methods, will be carried on.

New projects under the section of southern field crop insect investigations have been entered on during the fiscal year 1910. For many years the insect enemies of sugar cane and rice have levied their regular tax upon two of the more important agricultural industries. In 1902 the entomologist of the Louisiana Experiment Station estimated a loss of \$54,000 for the season on one plantation of 3,227 acres of cane. In 1908 it was ascertained from thoroughly reliable sources that the damage by a single insect on one sugar plantation near Brownsville, Tex., amounted to \$10,000.

Among the rice insects it is estimated that the root weevil was responsible for an annual loss in Texas alone of \$360,000. The fact that the boll weevil is forcing many planters to abandon cotton and put their land in sugar cane and rice gives additional importance to these enemies of these crops. The Bureau has obtained the services of Mr. D. L. Van Dine, formerly of the Hawaiian experiment station, to engage in a special investigation of sugar-cane and rice insects under Mr. W. D. Hunter. On account of the necessity of beginning the work near the middle of the crop season, in 1909, it will be possible to do little more than make a general survey during the remainder of the season. This will be carefully done; the special problems that need attention will be determined, and the best places for experimental work will be selected. This preliminary work will enable the agent in charge to undertake strictly control measures with the crop of 1910.

In connection with the work on sugar-cane insects, an investigation of the Argentine ant has been begun, and will be carried on throughout the year. The ant is a serious pest in houses, in orchards and gardens, and on cane fields—in the latter instance since it protects and cultivates the mealy bug of the sugar cane. During the fiscal year 1910 work on the ant will be restricted to the sugar-cane aspect of its habit. The cooperation of the entomologist of the Louisiana Agricultural Experiment Station has been obtained, and an agent has been stationed in Louisiana to devote his full time to the determination of the exact importance of the ant in its relation to the cultivation of sugar cane and, if possible, to devise practical means of control.

In connection with the investigation of insects affecting southern crops an incidental study will be made of the cotton red spider in South Carolina and adjoining States, and the cotton root-louse, which occurs in the same region. It is the opinion of the state entomologist of North Carolina that the root-louse is perhaps the most important insect enemy of cotton in that State.

The work upon cactus insects will be completed during the year, and work upon the life histories of ticks will be continued.

With forest insects the investigations of the past fiscal year will be continued. With insects affecting deciduous fruits the work in general will be a continuation of the lines already in progress. The pear thrips problem being practically solved, it remains only to carry on large-scale demonstration work, in order to show fruit growers exact methods and results. The work upon cranberry insects, the orange thrips, and codling moth will be continued. The work upon the grape root-worm will be practically discontinued, but work upon the apple maggot will be begun.

With the cereal and forage-crop work there will be no great expansion of the investigations, but work will be begun with a *Hemileuca* caterpillar damaging stock ranges in New Mexico and upon the alfalfa weevil injuring the alfalfa crop in Utah, as also with the leafhoppers affecting pastures.

PLANS OF WORK RECOMMENDED FOR YEAR ENDING JUNE 30, 1911.

In accordance with the request of the Secretary of Agriculture, no increases in the estimates for the year 1911 over the appropriations for 1910 are made. Some small changes of funds from one investigation to another are recommended. The practical completion of the pear-thrips investigation in California renders it desirable to reduce the sum set aside for the investigation of deciduous fruit insects by \$6,000, and to add that amount in part to the investigations of insects affecting forage crops, for the especial investigation of the *Hemileuca* caterpillar in New Mexico and the alfalfa weevil in Utah, and in part also to the fund for the investigation of forest insects, which needs additional assistance. There are very strong reasons for urging certain increases in promotions, but as the reasons for reducing the expenses of the Government seem even stronger, no recommendations in this direction are made.

Bureau of Entomology.

U. S. DEPARTMENT OF AGRICULTURE.

REPORT
OF
THE ENTOMOLOGIST
FOR
1910.

BY
L. O. HOWARD.

[FROM ANNUAL REPORTS OF THE DEPARTMENT OF AGRICULTURE.]



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1910.

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REPORT OF THE ENTOMOLOGIST.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., August 8, 1910.

SIR: I submit herewith an executive report covering the work of the Bureau of Entomology for the fiscal year ending June 30, 1910, dividing it, in accordance with your instructions, under the following headings:

(1) A summary of the important operations carried on during the fiscal year ending June 30, 1910.

(2) An outline of the plans proposed for work during the fiscal year ending June 30, 1911, under appropriations already made for that year.

(3) Plans of work recommended for year ending June 30, 1912.

Respectfully,

L. O. HOWARD,
Entomologist and Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

WORK OF THE YEAR.

The work of the year beginning July 1, 1909, and ending June 30, 1910, may be classified, as was the case last year, as follows:

- (1) Work on the gipsy moth and the brown-tail moth.
- (2) Importations of useful insects.
- (3) Exportations of useful insects.
- (4) Work on insects injurious to southern field crops.
- (5) Investigations of insects damaging forests.
- (6) Investigations of insects damaging deciduous fruit trees.
- (7) Cereal and forage-plant insect investigations.
- (8) Work on insects affecting vegetable crops.
- (9) Work on insects affecting citrus fruits.
- (10) Investigations of insects in their direct relation to the health of man and domestic animals.
- (11) Work on insects injurious to stored products.
- (12) Inspection work.
- (13) Work on bee culture.
- (14) Unclassified work.

FIELD WORK AGAINST THE GIPSY MOTH AND THE BROWN-TAIL MOTH.

The work against the gipsy moth and the brown-tail moth during the fiscal year ending June 30, 1910, has been continued along lines similar to those used in previous years, with a few modifications and additions. The infested area is somewhat larger, but the rate of increase is proportionately less than it has been in any year since the beginning of the work. Except for the finding of a bad colony of the gipsy moth at Wallingford, Conn., all the additions to the territory have been contiguous to the previously infested areas. The cooperation with the state authorities in the infested States has been most cordial and effective, and the livable conditions in the older infested areas are better than at any previous period since 1900. This means that the streets, roadsides, and cultivated lands are measurably free from both pests. Spread has been in forested areas, and looking away from the roadsides toward forested hillsides it was possible at any period during July to find large ranges of browned trees indicating the almost total removal of the foliage. As indicated before, however, the death of forest trees does not necessarily follow a complete defoliation in July, since the coming of rains in August brings out another crop of leaves, thus saving the trees from asphyxiation. Moreover, it is becoming evident that it is only rarely that the same area is completely defoliated two years in succession. It much more commonly occurs that the bulk of the caterpillars in a large infestation bringing about complete defoliation die as the result of disease from overcrowding, or from starvation owing to the complete destruction of food; hence the following season the new infestation begins on the borders of the old one, and contiguous rather than identical areas are defoliated.

The work, as in the past, has been confined chiefly to the gipsy moth. The infested area in New England is now little more than 10,500 square miles.

There has been little increase in the area infested by the brown-tail moth within the past year. The territory which this insect is now known to inhabit is about one-third of the extent of New England.

WORK IN MASSACHUSETTS.

The work in Massachusetts has been principally in the way of keeping the most traveled woodland roadsides through the worst-infested areas clear of the gipsy moth, and has been a continuation of previous work in nearly every direction, except south, where the conditions are not so serious as they are north and west of Boston. The roadsides which have been cared for more than one year are in such condition as to require a constantly lessening annual expense, and in a few instances additional work may be discontinued, since the roads are so clear that the towns are willing to care for them themselves. It seems that the Bureau may be able to induce the towns to take over more of the work which it has been caring for. As shown in previous reports, the strip on either side of the road which has been cleaned up has been 100 feet in width. Experimentally during the past year in several instances this width has been reduced to 75 and 50 feet. If these narrower belts prove to be effective in keeping the caterpillars from roadways, an extension of the number of miles of roadsides covered can be gained with the same appropriation.

Spraying operations were begun at the end of May and continued to the end of the fiscal year. Ten large spraying machines were kept at work in Massachusetts on the roadsides through the worst-infested woodlands, and some work was done in New Hampshire. The spraying was not so successful this year as last, on account of the unusual number of rainy days, the rain preventing the application of the poison and washing off much of that which was applied.

WORK IN NEW HAMPSHIRE.

No summer work was done in New Hampshire in 1909, but in the latter part of October scouting operations were begun, and an effort was made to keep 100 men in the State during the winter; but it was not easy to maintain this number on account of the difficulty of getting men who were willing to leave home. A severe blizzard and snowstorm late in December coated the trees and covered the ground to such a depth that scouting operations had to be discontinued temporarily. The work was continued into June, 1910. All of the previously known infested territory was scouted, but not so thoroughly as in previous years, the seriousness of the infestation in the southern part of the State rendering it desirable to spend the time in applying creosote to the egg clusters along the roadsides. The orchards and woodlands away from the highways were not touched.

During the fiscal year 1908-9 about 50 towns were added to the infested area; the present year 21 were added as the result of this careful scouting. In several of these new towns only single egg clusters were found, and in none of them were there any large colonies. There are at present 121 infested cities and towns in New Hampshire, with an area of about 3,500 square miles. There seems to be little hope of controlling the gipsy moth in New Hampshire until a local organization is effected in each city and town, under state supervision, and a constant concerted effort is begun. The scouting operations were continued outside the area found to be infested, in order to make certain that there has been no further spread.

The brown-tail moth situation in New Hampshire was found to be serious. The winter nests were removed from the highway trees in most of the towns, and many property owners cut them from orchard and shade trees near their dwellings, but here again there is necessity for concerted state and township work.

WORK IN MAINE.

In Maine the trees in the infested localities were burlapped and tended. The worst places were sprayed. In most of the woodland colonies the underbrush has been cut out and the trees put in the most favorable condition possible. Scouting operations were continued throughout the winter and spring months. Four towns were added to the infested area, but in these only incipient infestations were located, the worst one being at a market garden in South Portland, where 22 egg clusters were found and treated with creosote. All of the known infested localities in this State are in shape for future work. The territory now known to be occupied by the gipsy moth in Maine is about 800 square miles. The gipsy moth colony previously existing, and referred to in earlier reports, at Soldiers' Home,

Togus, Me., may be considered as exterminated, no evidence of the moth having been found for nearly two years.

During the past winter considerable woodland scouting was carried on, and large gipsy moth colonies were located in a few places, the worst one being on the eastern slope of Agamenticus Mountain, in the towns of York and Wells. Several thousand egg clusters were treated with creosote in this colony, and the ground was cleared up over several acres. A smaller colony was located near the summit of the mountain. Several woodland colonies were located in the Berwicks, but Maine conditions in general are not bad.

The brown-tail moth seems possibly to have reached the northern limit at which it can thrive in Maine, which is about the forty-fifth parallel of latitude. Although the moth has been known to be present up to this line for two or three years, it does not appear to increase materially. This statement must not be taken as a prediction that the brown-tail moth will not extend north of this region, but simply as a statement of observed fact down to the present time.

WORK IN RHODE ISLAND.

The area infested by the gipsy moth in Rhode Island has decreased slightly during the past year, and the moth is less abundant than at any time since its control was undertaken. The Bureau work in this State has been in cooperation with the state officials. The state appropriation is used until it is exhausted, and then such of the force as is necessary to keep up the work is carried on the federal pay roll through the season. The creosoting of egg clusters and the burlapping of trees has been the principal work. A little brush has been cut and a great many trees have been cemented or patched with tin to lessen the number of hiding places for the caterpillars and egg clusters.

The brown-tail moth has been more in evidence in Rhode Island during the past year than before, and now occurs in about one-fourth of the State—the northeastern portion—although here it is not as prevalent as in Massachusetts, New Hampshire, and Maine.

WORK IN CONNECTICUT.

The gipsy moth colony at Stonington is nearing extermination. Less than 100 caterpillars were taken there during the summer of 1909 by the state force. Early in December some of the best scouts employed by the Bureau were sent to this State to assist the state authorities in the search for egg clusters, the combined efforts resulting in the discovery of but one. While this colony will need watching for some time, it seems probable that another year or two should result in its complete eradication.

In December, 1909, a bad colony of gipsy moths was discovered in the town of Wallingford, about 12 miles north of New Haven. The State immediately took steps to do the necessary work, and a little later a force of Bureau scouts was sent down from Massachusetts to examine the territory outside of the lines of the original colony. Every tree in Wallingford was examined, except the woodland, and no egg clusters were discovered except a few near the border of the colony, as at first outlined. The scouting operations were continued

in the towns of Meriden, Berlin, and New Britain, but no evidence of the existence of the gipsy moth has been found in these towns. It is hoped to continue this line of scouting operations to the Massachusetts state line in the towns through which a great deal of traffic passes from the infested area in Massachusetts to New York. This is one of the principal automobile routes in New England. All effort to ascertain how the gipsy moth reached Wallingford has been vain. The colony has existed for about three or four years, and possibly longer, entirely undiscovered until last December. About 10,000 egg clusters were destroyed before hatching time. The State is doing all of the work in the infested area.

The brown-tail moth has been reported from Thompson, in the northeast corner of the State, and also at Putnam, a few miles south of Thompson. It is possible that this region south of the Massachusetts line is rather generally infested.

GENERAL CONSIDERATIONS.

There have been employed throughout the year from 300 to nearly 500 men. First-class men have been difficult to get, and in February an increase was made in the wages of all of the older men, of from 1 to 3 cents per hour. There have been in use 10 gasoline-power spraying machines, of 400 to 500 gallons capacity, capable of discharging 3,000 to 4,000 gallons per day, and about 40 tons of arsenate of lead have been used during the past spraying season.

The use of burlap bands for trapping the caterpillars on the tree trunks has been discontinued, and tree tanglefoot has been substituted, 20 tons being used during the summer work of 1910. In an effort to reduce the cost of this operation, similar substances have been introduced from Europe, but have not proved to be as effective as the tanglefoot in the prevention of the crawling of the caterpillars.

Some investigations have been begun in regard to certain points connected with the life history of both the brown-tail moth and the gipsy moth, which, although hitherto considered settled, now seem open to some doubt.

The principal subject of this kind which has received attention has been undertaken in an effort to explain the presence of the gipsy moth in isolated woodland colonies which it could not possibly have reached by the crawling of the caterpillars and which it is most unlikely to have reached by being carried accidentally on the garments of persons penetrating the woods. Thus a series of experiments has been carried on in a most careful way to determine whether the newly hatched gipsy moth caterpillars may be distributed by the wind, and it has been possible to prove during the summer that the newly hatched caterpillars have been carried in this way over a distance of 1,800 feet.

The methods used in the entire work, together with new observations bearing upon the work, have been summarized in a bulletin about to be published, entitled "Report on the Field Work against the Gipsy Moth and the Brown-tail Moth," by D. M. Rogers and A. F. Burgess. One new point brought out is that August spraying is an excellent method for the control of the brown-tail moth. The collection of the winter webs, which is the method universally adopted in Europe and which has also been generally practiced in this

country, necessitates the constant cutting back of the twigs and smaller branches, which, where the moths are so plentiful as to make their webs upon almost every twig, must be to some extent injurious to the trees.

Although there is a general section in this report devoted to inspection work, it is proper here to mention the efforts made to prevent the further dissemination of the gipsy moth from the infested territory by the cooperation of the different railroads running through this territory. Beginning with the fiscal year 1909-10, the several railroads issued a notice to all of their station agents (about 600 in number) within the infested area to the effect that forest products, such as lumber, cord wood, railroad ties, telephone poles, etc., would not be received for transportation unless accompanied by a permit or a certificate of inspection. The effect of this order was some disturbance to shippers for a time, but, as they learned the object of the inspection and saw the possibility of relieving others of similar inconvenience, they have gladly cooperated. A trial of this plan indicated that it was nearly impossible to inspect all of the material offered for shipment, and permits were granted without inspection for the transportation of forest products from one infested locality to another infested locality, but all of the products intended for shipment beyond the infested territory were carefully inspected and all egg masses were destroyed before the material was moved and before a certificate was granted to the shipper. In December, 1909, a supplementary order was issued by the railroads to their station agents stating that forest products for shipment from one station to another within the infested territory might be received and shipped without permit or certificate. This order properly gave a list of the stations on the several roads between which material might move, but forbade the transportation of forest products from the stations listed to stations not listed, except when accompanied by a certificate. Three thousand four hundred and seventy-five applications were made for shipment, and 2,751 permits were granted, 724 certificates being issued. This system has worked fairly satisfactorily, although it is not perfect.

The actual field work just described has been carried on under the direction of Mr. D. M. Rogers, as in previous years. Mr. Rogers's headquarters are at No. 6 Beacon street, Boston.

IMPORTATIONS OF INSECT ENEMIES OF THE GIPSY MOTH AND THE BROWN-TAIL MOTH.

The principal efforts of the Bureau in importing useful insects during the fiscal year 1909-10 have been in connection with the importation of the parasites and predatory enemies of the gipsy moth and the brown-tail moth from other parts of the world. This work has been in cooperation with the State of Massachusetts, and the parasites have been received at the Gipsy Moth Parasite Laboratory, supported by the State, at Melrose Highlands, the care of the parasites and their distribution being assigned to the Bureau of Entomology. The laboratory has been increasingly busy and increasingly effective, and during the fiscal year has employed 23 assistants, the principal experts being carried on the rolls of the Bureau of Entomology and the others being paid by the State. Mr. W. F. Fiske, of the Bureau, has had direct charge of the work.

The writer visited Europe in May and June, 1910; visited agents and officials in Italy and France, and, through the courtesy of the Spanish and Portuguese governments, was able to start a new official service in each of these countries for the collection and sending of parasitized gipsy moth larvæ to the United States. In Italy Prof. F. Silvestri, of the Royal Agricultural College at Portici, and Dr. Antonio Berlese, director of the Royal Agricultural Entomological Station at Florence, insisted on the desire to be of service to the United States in this direction and declined all financial aid. In Spain Prof. L. Navarro, of the Phytopathological Station at Madrid, volunteered his services under the same conditions, with the approval of the minister of agriculture. In Portugal, Prof. A. F. de Seabra, of the Phytopathological Station at Lisbon, also volunteered his services with the permission of Senhor Alfredo Carlos Le Cocq, director of agriculture. In France arrangements were made with a paid agent stationed in the south of France, and the same arrangements as in previous years were made with paid agents in Germany and Switzerland. The distributing agency at Hamburg was continued, and a new distributing agency was started at Havre on account of its convenient proximity to the American Line steamers starting from Southampton.

Sendings from Japan were continued in the same manner as during the previous year. The minister of agriculture for Japan, at the request of the Secretary of Agriculture of the United States, again designated Prof. S. I. Kuwana, of the Imperial Agricultural Experiment Station at Tokyo, to be its official representative in the work to be carried on during the spring and summer of 1910. Professor Kuwana continued his most valuable sendings.

The thanks of the United States Government and of the governments of the States involved are due in high measure to the officials of Italy, Russia, France, Spain, Portugal, and Japan who have assisted in this work. All of them have been named at one time or another in this series of reports.

The work of the Gipsy Moth Parasite Laboratory continued uninterruptedly during the year, consisting of—

(a) Importation of parasites and predatory enemies from abroad, as indicated above.

(b) Rearing these parasites and predatory enemies in the laboratory, and wherever possible breeding them in numbers from imported parent stock.

(c) Colonization in the field of the parasites thus obtained.

(d) Field work to determine their progress in America.

(e) Investigations into their biological and general relations.

(f) Field and laboratory investigations into the parasites of native insects most nearly related to the imported pests either in habit or in natural affinity, with especial reference to the probable effect which the introduction of the foreign parasites will have upon the economy of the native parasites and of their hosts.

Larger quantities of the raw material from which the parasites have been reared have been received than during any other year. This has consisted, as heretofore, of eggs, winter nests, caterpillars, and pupæ of the brown-tail moth from Europe, and of eggs, caterpillars, and pupæ of the gipsy moth from Europe and Japan, large numbers of adult predatory beetles, and thousands of parasite cocoons and

puparia. But, for numerous reasons, although the amount received was larger, the results obtained, owing partly to the condition of the material on receipt and owing to curious seasonal fluctuations and differences in the countries of origin and in the infested territory in America, the results have by no means corresponded with the increased material.

During the year 1909 two important parasites of the gipsy moth (*Blepharipa* and *Parasetigena*) were imported in large numbers. They were both hibernated successfully and colonized under ideal conditions in the spring of 1910.

During 1910 determined efforts have been made to secure adequate numbers of several interesting and probably valuable parasites not yet secured in quantities sufficient to provide for satisfactory colonies; but for the most part these attempts seem to have resulted in failure, although the final word can not be said at this time.

As the work goes on there seem to be almost as many disappointments as successes. For example, no less than 1,000,000 of a Japanese parasite of the eggs of the gipsy moth were reared during the summer of 1909 and the winter and spring following, and great hopes were entertained for its success, but from the present point of view it appears to be wholly unable to withstand the rigors of the New England winter, and another egg parasite, a European species, of which several hundred thousand were reared in confinement, does not appear to make an impression upon the numbers of the gipsy moth eggs in America.

On the other hand, success of the most promising character has been reached with others of the imported species. *Calosoma sycophanta*, an imported European predatory beetle, was the first of the imported species to be recovered from the field under circumstances indicative of its ability to exist under American conditions. The season of 1910 is the fourth during which its progress has been conscientiously followed, and during each of these seasons it appears to have combined a steady rate of increase of approximately tenfold with a rate of dispersion in excess of 1 mile a year in every direction from the center of the original colony. A tenfold rate of increase annually means that 100 beetles liberated in 1906 would have increased to 1,000,000 by 1910, and the actual prevalence of the beetle in the field is such as to make this appear a reasonable estimate of the numbers actually existent. They were so abundant in some localities the past year as to affect the gipsy moth materially, although by no means so materially as to meet and overcome the strong reproductive ability of the pest. If, as there is reason to hope, they will continue to increase at this slow but steady rate for some years to come, their effect upon the present prevailing abundance of the moth will be apparent to all.

Another encouraging example is the tachinid fly of the genus *Compsilura*, which attacks both the gipsy and the brown-tail caterpillars as an internal parasite. This species was first liberated in 1906 and was first recovered in 1909 under circumstances indicative of its establishment in America. During 1909 it was found distributed over about five towns adjacent to the one in which the first infected colony was liberated. It was everywhere rare during that year. In 1910 it was expected that it would show a marked increase, but the actual outcome was in excess of all expectations. Instead of a ten-

fold increase, which would have been considered satisfactory, there seems good evidence that it increased fiftyfold and perhaps much more. It has about equaled *Calosoma* in actual destruction of gipsy moths this year, and in addition has destroyed an appreciable percentage of the brown-tail caterpillars, and it is now turning its attention to such native species as the fall webworm, the tussock moth, and other fall-feeding caterpillars. Its increase has been accompanied by a dispersion amounting to 10 or 12 miles in every direction as a minimum aggregate during the four years since its first colonization.

Still another example is the European *Monodontomerus*, the recovery of which over a large area was made the subject of especial mention in the last report. This species has continued its satisfactory rate of increase and phenomenal rate of dispersion throughout the year. It is well over the border line in New Hampshire, and appears to be extending its range about 10 miles each year, and to be maintaining a twenty-five fold annual increase.

It has been somewhat disheartening in the course of the study of the progress of the parasites in the field to find that certain species liberated under the most favorable conditions can not be recovered the next year; and even in the case of two species, both colonized in 1908 and apparently established in 1909, no traces could be recovered in 1910. But on the other hand another species (*Zygobothria*), colonized in 1907, was recovered in 1910, three years later, for the first time—in small numbers, it is true, but over a considerable territory, indicating a rapidity of dispersion sufficient to render a material increase unnoticeable for the first two years.

Another encouraging fact which may be mentioned here is that an important egg parasite (*Anastatus bifasciatus*) seemed this summer to have demonstrated its ability to survive the New England winter, and, having been colonized in 1909, appears to be strongly established in 1910.

On the whole, the results of the work are distinctly more encouraging than they have appeared to be heretofore, and we are by no means disheartened over the nonrecovery during the present season of no less than 15 species which have been colonized. In several instances colonization has been much too recent to make their recovery probable, on account of rapid dispersion; and several others have never been received in sufficient numbers to make a strong colony possible, so that it may well be that establishment has not yet been accomplished. It has been found in the course of this work that there is little hope of the establishment of a colony of less than 1,000 individuals, and in many instances, of course, it has been found impossible to put out so large a number.

The insight which is being gained at the laboratory into many points connected with the biology of these important and interesting insects is resulting in practical knowledge that can not fail to be of high importance in the continuation of the investigation. Some changes in plans will be indicated in another part of this report.

OTHER IMPORTATIONS OF USEFUL INSECTS.

The greatly increased damage done in portions of Massachusetts by the European leopard moth, an insect whose larva bores into the limbs of many shade trees, and which at present is confined to eastern

Massachusetts and to the vicinity of New York City, has rendered it desirable to attempt the importation of some of the known European insect enemies of this species. This effort has been made during the fiscal year, but it is too early as yet to observe any result. Further attempts were made to introduce European enemies of the elm leaf-beetle, but as yet without success.

It has been ascertained that the eggs of the tobacco hornworm in Porto Rico are destroyed by parasites, and in consequence, through the courtesy of Prof. W. V. Tower, a large number of parasitized eggs were sent to Clarksville, Tenn., the headquarters of the tobacco-insect investigations of the Bureau. The parasites emerged in due time, but through some defect in manipulation that may be remedied as a result of future work none of them could be induced to attack the native eggs.

EXPORTATIONS OF USEFUL INSECTS.

Prof. Antonio Berlese, of Florence, Italy, reports the continued spread of the American parasite of the mulberry scale and anticipates complete relief.

Exportations of American coccinellids have been made to Prof. F. Silvestri, of Portici, Italy, for the purpose of feeding upon this same scale insect. These coccinellids have been reared at Portici and have been liberated in mulberry groves at Acerra. The Chief of the Bureau, visiting in Italy in May, 1910, took with him a large box of these American coccinellids, which arrived at Portici in almost perfect condition, and from them Professor Silvestri expects excellent work.

Shipments of the parasite of the brown dog tick were made to officials in South Africa and to Italy.

WORK ON INSECTS AFFECTING SOUTHERN FIELD CROPS.

The work on insects affecting southern field crops deals with the following problems, in accordance with the classification made a year ago:

1. The cotton-boll weevil and other species injurious to cotton.
2. Insects injurious to tobacco.
3. Insects injurious to sugar cane and rice.
4. The Argentine ant.
5. Insects injurious to cacti utilized for food.

This work is conducted, under the direction of Mr. W. D. Hunter, by four trained assistants, located, in so far as possible, in the regions where the loss is greatest.

COTTON-BOLL WEEVIL INVESTIGATIONS.

The growing season of 1909 was very abnormal as regards damage by the boll weevil. Although the infested area increased as usual in the autumn, the damage in general was much less than is to be expected in a normal year. An unusually small number of weevils issued in the spring, owing to abnormal winter conditions. Unprecedented dryness, which began early in the spring, was continued throughout a large part of the growing season and checked rapidity of multiplication. Considerable damage, however, was done in

southern Texas and in the southern parishes of Louisiana. Considerable damage was done also in Mississippi. A conservative estimate of the loss will be about \$15,000,000.

On account of the obviously greater difficulty of the boll-weevil problem in the Mississippi Delta than elsewhere, as pointed out in previous reports, a well-equipped laboratory was started at Tallulah, La., where conditions characteristic of the whole delta region exist, and during the year substantial progress was made in the study of new means of control. Especial attention was paid to the possibility of utilizing parasites of the boll weevil. On account of the scarcity of material for breeding parasites in Texas it was impossible to carry the work as far as was desired. Nevertheless some practical indications of success have been obtained.

An important series of experiments was begun to determine the proper spacing of cotton plants in the field in order to obtain the maximum benefits of the factors in the natural control of the pest, including the parasites. These plots were located at five points in Louisiana.

The chain cultivator, perfected by the Bureau, was tested with especial reference to its adaptability to the peculiar soil conditions of the delta, and a study was made of the possibility of flooding the fields to kill the weevils in their hibernating quarters. This method will probably be practicable in some localities.

In connection with the utilization of the parasites of the weevil a study was made of the relative abundance of the flow of nectar with the different varieties of the cotton plant. This nectar furnishes the only food, so far as known, of the adult parasites. Therefore the cotton varieties that secrete the most nectar may be supposed to attract the parasites which will destroy the weevils. Also the cotton varieties which hold the squares best have been found to be more heavily parasitized than other varieties of cotton plants. Therefore a study of varieties having this habit has been carried on.

Extensive experiments were made in the effort to obtain definite knowledge regarding the hibernation of the weevil in the delta. The results obtained from these experiments will indicate the best time to take the greatest step in the control of the boll weevil, namely, the destruction of the cotton stalks in the fall.

Efforts were made also to ascertain the exact effects of excessive moisture on the hibernating insects, since it has been suggested that the heavy precipitation in the delta region may be unfavorable to the weevil during the hibernation period.

On account of the apparent success of experiments made by the Louisiana state crop pest commission with powdered arsenate of lead, experimental work in this direction has been carried on by the Bureau. Arsenate of lead is a very finely divided powder, and will reach parts of the plants that can not be reached by Paris green or other compounds hitherto used. An effort was made to ascertain how many applications are most profitable and the proper interval between applications. The experience of practical planters in using the poison has been collated. Work of this character was also begun in Texas. An important objection against the use of arsenate of lead is its high price, and, moreover, recent experiments seem to indicate that its effect upon the soil under some conditions may be very deleterious. The Texas experiments include a study of arsenical

and other poisons made up especially by certain manufacturers in the hope of discovering a cheaper compound and one which at the same time will possibly have less direct injurious effects upon the soil.

TOBACCO-INSECT INVESTIGATIONS.

The section of the southern field-crop insect investigations dealing with tobacco insects had its headquarters, as last year, in Clarksville, Tenn., and the work dealt largely with the control of the two species of hornworms of tobacco. An important addition was made to the knowledge of the life history of the hornworms. It was found that the emergence of the moths from the ground in the spring extends over a long period—in fact, until August. It has been supposed that the moths appearing in August were of the second generation, and hence it was argued that large numbers of the first generation of the worms must have escaped destruction by the poisons used. It was thought by planters that it would do little good to attempt to destroy the insects in hibernation, because a large number of worms would escape on young tobacco and in the next generation cause the so-called "August shower of worms." It was found that a comparatively small percentage of the overwintering insects emerge before the end of June—in fact, in 1909 only 4 per cent issued before this time. The last individuals emerging produce a generation of such numbers as to injure tobacco seriously by August 1. During the eleven days from July 30 to August 9, 50 per cent of the hibernating pupæ became adult, and about 8 per cent became adult later. This emphasizes greatly the importance of taking all possible means toward the destruction of the hibernating forms—a move which the planters have hitherto been disinclined to make.

The usual means of controlling the hornworm has been the use of Paris green, but this poison is objectionable on account of injury to the leaf. Arsenate of lead, which does not injure the leaf, kills the insects so slowly that it is objectionable. A form of arsenate of lead has been found, however, which has not this disadvantage, and experiments were conducted with a number of other poisons which promise to be of practical value.

Experimental work against the tobacco flea-beetle was continued, in the way of application of sprays and dust in the plant beds, the dipping of the plants at the time of transplanting, and the application of various poisons both in dust and spray form to plants in the field. The improvement of the seed beds to avoid attack was also studied.

Further investigations on the so-called wireworm of tobacco were carried on at Appomattox, Va. It was found that the insect occurs in great numbers on several wild plants, but the great majority on two species which grow in fallow fields and waste places. It seems obvious that the elimination of these two weeds by cultural process or otherwise would go far toward reducing the injury to tobacco. The greatest damage was found where tobacco was planted on fields in which these weeds had occurred in the greatest numbers. Rotation, therefore, and the keeping down of weeds promise good results.

Further work has been done upon the tobacco thrips and the splitworm in Florida, but it was impossible to conduct this work continuously.

The work on the cigarette beetle, an important pest in tobacco warehouses, mentioned in the last report, was continued. Consideration has been given to fumigation with different gases at different temperatures, and an effort was made toward devising a new form of package for tobacco that would prevent the entrance of the pest.

SUGAR-CANE AND RICE INSECT INVESTIGATIONS.

The investigations of sugar-cane and rice insects, commencing July 1, 1909, consisted mainly of a preliminary survey of the species affecting these crops, and the beginning of work on the more important enemies that were found. The sugar-cane areas of Louisiana, Texas, and Florida were visited, as well as the rice-growing regions in Louisiana, Texas, and Arkansas. A laboratory was established in Louisiana, and quarters were provided by the Louisiana sugar experiment station, at Audubon Park. The Bureau has been fortunate in enlisting the active cooperation of the Louisiana state experiment stations in this work. This laboratory will be the headquarters for the sugar-cane and rice insect investigations for the South generally, and, as regards Louisiana, will be in direct cooperation with the state officials. The results of the work at this laboratory will apply in a general way to the areas in the entire sugar-cane and rice belts, with the exception of the sugar-cane areas in the Rio Grande Valley in southern Texas and those in southern Florida. Because of the open winters in these districts, by which the insect pests are able to develop continuously, particular consideration must be given to special methods of control.

Work was begun upon the sugar-cane stalk borer, the root beetle, the sugar-cane mealy bug, and the root weevil or maggot of rice. It is estimated that the annual loss through insect pests on sugar plantations in Louisiana reaches \$1,500,000; in the Rio Grande Valley the percentage of loss from the sugar-cane stalk-borer is probably as high, and the annual loss from insects injurious to rice in Louisiana, Texas, and Arkansas is estimated to be \$966,000. These figures will illustrate the importance of these investigations.

ARGENTINE ANT INVESTIGATIONS.

At the beginning of the fiscal year work on the Argentine ant was undertaken. Mr. Wilmon Newell, formerly secretary of the state crop pest commission of Louisiana, who had done the principal work upon this species in this country, consented to collaborate in this work, and an expert agent was appointed and placed at Baton Rouge, La. The main line of investigation was the relation between the ant and the sugar-cane mealy bug, the control of which seems to be complicated by the ant. At the same time efforts were made toward obtaining information regarding other features of the injury by the ant. The insect is of such importance in so many different ways that its life history must be investigated from every standpoint. Aside from this life-history work, experiments were begun in orange groves in lower Louisiana in the effort to control it by means of traps and the flooding process. This ant has threatened to destroy the orange industry in the parishes of lower Louisiana. In fact, many of the groves have been abandoned. The trap and flooding experiments

were very encouraging, and it is believed that a practical method of control can be perfected. Attention was also given to the question of preventing the spread of the ant in the United States.

OTHER WORK.

During the year as much attention as possible was paid to the cotton red spider in South Carolina and other States. It appears that this is a pest of more than local importance. Moreover, it is especially important to devise means of reducing injury by the red spider, on account of the invasion by the cotton-boll weevil which will take place before many years have passed. An agent was placed in South Carolina in the fall and in the spring, and experimental work was begun which will be carried through the coming year. The principal hope seems to be for cultural methods, the perfection of which will require some little time.

The investigation of insects injurious to cultivated cactus was practically completed during the year. A few observations and experiments must be repeated on account of the unusual weather conditions of the last year. In several cases good methods of control have been found. Insects interfering with the development of cactus as a farm crop will probably be controlled as a result of this investigation.

INVESTIGATIONS OF INSECTS DAMAGING FORESTS AND FOREST PRODUCTS.

In the course of the Bureau work on forest insects, Dr. A. D. Hopkins in charge, investigations of special problems have been carried on by experts and agents in Colorado, Montana, Oregon, West Virginia, Virginia, Maryland, New York, New Jersey, South Dakota, and Ohio. Information has been given to correspondents in nearly all of the States and Territories, and to forest officials in 62 national forests. Cooperation in the inauguration and demonstration of practical control has been carried on with the Forest Service in certain of the national forests of Colorado, Montana, and Oregon, with the Department of the Interior in a national park, on the public domain in Montana, and with private owners of timber in Montana, Washington, and Oregon; also with manufacturers of agricultural implements, machinery, and vehicles in Ohio, Indiana, and Illinois, and with the state entomologist in a forest insect survey of Illinois.

PRINCIPAL DEPREDACTIONS.

The principal depredations during the year have been the continued and extensive damage to living timber in the Rocky Mountain and Pacific slope regions by the Black Hills beetle and the mountain pine beetle on the pine, by the Engelmann spruce beetle on the spruce, and by the Douglas fir beetle on the Douglas fir. An enormous amount of choice timber has been killed during the year, and a threatened destruction of the larger trees in whole forests in Montana, Idaho, Washington, California, and Colorado can only be avoided by prompt and radical action by the Government, state officials, and private owners. Damage to the wood of important hardwood timber in the forests east of the Mississippi River has continued practically

unchecked, and is probably on the increase, owing to the present methods of lumbering and general management of forest land.

PRACTICAL APPLICATIONS AND RESULTS.

While there is evidence that some of the information on practical methods of preventing losses is being utilized to the best advantage to reduce the cost and increase the profits to owners and operators, which will ultimately lead to reduced cost to the consumer and the better protection of the resources, it becomes more and more apparent that, in order to convince the majority of the people who would derive the most benefit that the information is of real practical value to them, they must be shown. They either have not read the publications or asked for information, or they have not appreciated the importance of adhering to the essential details of the recommendations. Therefore, it has been necessary to carry on a certain amount of demonstration work and for the experts to give direct instructions and advice in the field.

This line of educational work carried on during the past four years has shown most gratifying results during the past year, especially in proving that the methods recommended may be easily understood and properly applied by owners of timber, government forest officials, and managers of manufacturing enterprises, and that the desired results can be secured through the proper expenditure of a comparatively small amount of money and energy.

The areas in Colorado in the vicinity of Colorado Springs, Palmer Lake, Idaho Springs, and on the Trinchera estate and Las Animas National Forest, where the control work directed against the Black Hills beetle was completed at various times since 1905, as mentioned in preceding reports, have been examined during the past year, and, as indicated by the failure to find dying or infested trees, the successful control work continues to have its protective influence.

The control work against the Black Hills beetle in the Wet Mountains section of the San Isabel National Forest, Colorado, completed at the close of the fiscal year 1909, was found, upon examination during the present year, to be a complete success, as were also the control operations in and adjacent to the Jefferson National Forest, Montana, which were started in June, 1909, and completed in July of the same year.

The evidence gathered from the results of the investigations and control work relating to these six cases indicates that the proper disposal of a total of some 4,000 trees within the areas during a period of four years at a first cost of about \$2,000, or an average of 50 cents per tree, has ended depredations, which, during a preceding period of ten years, had caused an average death rate of more than 7,000 trees per year, or a total of 7,000,000 feet, board measure, having a stumpage value of \$14,000.

The work carried on in cooperation with private timber owners and forest officials in northwestern Montana, inaugurated last fall, has yielded most satisfactory results, especially in the fact that the private owners have been made to realize the importance of prompt action to prevent the total destruction of the remaining merchantable timber. This has led to the proper treatment by cutting and barking or otherwise disposing of between 9,000 and 10,000 beetle-infested

trees by ten or more of the owners. This, it is believed, will be sufficient to control the depredations over an area of more than 100 square miles in which the timber has been dying at an alarming rate during the past ten or fifteen years. It will also have a marked effect toward protecting the timber of the adjacent areas of the national forests in which like depredations have been going on. The Department of the Interior has allotted sufficient money to take the immediate action required to control the depredations in the southwestern section of the recently established Glacier National Park. It is expected that the Forest Service will take the necessary action within the Flathead and Blackfoot National Forests during the coming year to dispose of a sufficient amount of beetle-infested timber, in addition to that disposed of by private owners and the Department of the Interior, to effectually check the depredations throughout the entire area, thus ending the losses of timber which have been progressing in this general region during the past ten years at a death rate of at least 200,000 trees annually.

IMPORTANT NEW WORK.

During the close of the year there has been organized the most extensive cooperative project for the control of barkbeetle depredations that has ever been undertaken in this country. It is designated as the Northeastern Oregon and Western Idaho Project and involves an area of over 13,000 square miles. The object is to undertake the control of the barkbeetle depredations on the living timber of the national forests and adjacent private and other lands through co-operation between the Bureau of Entomology, the Forest Service, and private owners. The plan provides that the experts of the Bureau of Entomology shall make the investigations of the insects, recommend methods of procedure in control work, and give special instructions and advice relating to the essential details, while the Forest Service and timber owners provide the funds required for the actual control operations.

The experts of the Bureau have already determined that the depredations are so extensive within the area and the time so limited before the beetles begin to emerge from the tens of thousands of infested trees to attack the living timber, that it is not practicable to undertake control work against the present (1909-10) infestation. It is believed, however, that the whole area can be sufficiently worked over and enough trees involved in the new (1910-11) infestation located, marked, and disposed of before the 1st of July, 1911, to effectually check, if not control, the depredations—thus preventing the further loss of timber which has been going on during the past five or six years at the estimated rate of nearly a million trees per year.

INVESTIGATIONS OF INSECTS DAMAGING DECIDUOUS FRUIT TREES.

The investigations of insects affecting deciduous fruits and vineyards, under the direction of Mr. A. L. Quaintance, have included the continuation of projects under way during 1909, and beginning with the spring of 1910 some additional lines of work have been taken up.

THE PEAR THIRPS.

The results of the Bureau's studies and experiments in the control of the very destructive enemy of deciduous fruits in California known as the pear thrips were set forth in the last report. It was found possible to destroy a large percentage of the total thrips in a given orchard by spraying with a tobacco and distillate spray in the spring, before the opening of the blossoms. Excellent results were also obtained in the destruction of the helpless pupæ in the soil by deep plowing and cross plowing in the fall.

In the fall of 1909 special attention was given to demonstrating on a large scale the benefits of plowing in the control of this insect, and in the spring of 1910 spraying operations were carried out in several parts of the infested territory. The Bureau's agents had full charge of several orchards or parts of orchards, and in addition acted in a supervisory manner over the work done by a considerable number of orchardists. In this way a large amount of remedial work was accomplished, and the active interest of many orchardists in Santa Clara, Contra Costa, Solano, Sacramento, and other counties has materially strengthened the Bureau's work. Thus, in the territory adjacent to Walnut Creek there were sprayed about 220 acres of pears, 100 acres of prunes, and 30 acres of cherries; in the Suisun territory 200 acres of pears, 190 acres of cherries, and 60 acres of prunes; and in the Courtland district 200 acres of pears and 20 acres of cherries; a total in the district to the north of San Francisco of 620 acres of pears, 160 acres of prunes, and 240 acres of cherries.

In the Santa Clara Valley the Bureau's work proper included thorough plowing of about 100 acres and the spraying of about 70 acres of orchard. There were plowed, however, under the advice of the Bureau, about 1,650 acres, and in a similar manner 540 acres of orchard were sprayed. This work on the whole has yielded about as successful results as were obtained the year previous. However, the benefits have been somewhat obscured on account of the serious injury to the prune crop by late spring frost. There is, unfortunately, often a tendency on the part of orchardists to attribute to any injurious insects that may be present the losses resulting from unfavorable weather conditions. It is proposed to take the yield of fruit from sprayed and unsprayed blocks in the orchards under treatment and thus secure definite figures as to the benefits of the work which may be expressed in dollars and cents.

Along with the demonstration and experimental field work, a considerable number of other sprays have been tested as they were sent in by persons believing them to be of value or which have been made according to formulas suggested. None of these, however, has proven equal to the tobacco and distillate oil spray mentioned, and this has become the main reliance. Attention has also been given to obtaining additional information on various points in the life history of the insect, especially in orchards, as to its migration and ground habits, and its distribution in different types of soil. It seems possible that in the deeper alluvial soils, as in the Courtland district, the value of thorough plowing will be materially lessened for the reason that the larvæ are able to penetrate to a considerable depth and below the reach of plows. Our knowledge of the insect, however, is now very

complete and covers its behavior during the entire year. A complete report on the investigations in the field and laboratory during the past three years is now in course of preparation.

THE CODLING MOTH.

Studies of the codling moth on apple have been continued along lines previously reported. The experiments undertaken in the spring of 1909 in a comparison of the so-called one-spray method, in use in the Northwest, with the practice of spraying generally followed in the East, were concluded and a large amount of data on the subject accumulated, the results of which have already been submitted for publication. In general, it appears that about as good results may be obtained by the one-spray method, in so far as the control of the codling moth and curculio is concerned, as by several treatments applied in the customary way. Notwithstanding these results obtained by the one-spray method, however, the plan is not considered to be of special importance under eastern conditions, for the reason that in this territory it is necessary in nearly all cases to make several applications of a fungicide during the course of the season for the control of fungous diseases, and under these circumstances the addition of an arsenical is, of course, desirable. However, the work points out unmistakably the great importance of much more thorough spraying at the time of the falling of the petals and under a higher pressure than has generally been given heretofore. Further tests of the one-spray method are in progress in Virginia and Michigan, and it is hoped that a final report may be prepared at the close of the present season from the data secured.

The experiments in Missouri and Arkansas orchards in cooperation with the Bureau of Plant Industry of this Department, and mentioned in the last report, comprising a comparison of dusting versus spraying in the control of the codling moth, plum curculio, and fungous diseases, were concluded in the fall of 1909, and report upon the work is in preparation. It appears that the use of dust sprays for the codling moth, curculio, and other apple insects gave results very much inferior to those obtained by the use of liquid sprays, and the dust sprays are notably ineffective in the control of fungous diseases. Thus, in Missouri the yield of merchantable fruit from dusted plats was approximately 3 per cent of the crop as compared with 86 per cent of merchantable fruit on plats sprayed with Bordeaux mixture and arsenate of lead.

Life-history studies of the codling moth in important fruit regions are being continued as heretofore, as in California and Michigan. The studies in progress during the last two seasons in northwestern Pennsylvania have been completed and a report upon the work is now in press. This investigation brought out forcibly the influence of temperature on the extent of, and injury by, the larvæ of the second brood. Thus, during the season of 1907 the proportion of first-brood larvæ to transform into adults was 3 per cent, whereas during the season of 1908 the proportion transforming was 67.7 per cent, a difference due entirely, it is believed, to the widely different seasons which prevailed during these respective years. Similar studies have been made in the Ignacio Valley, in California, in connection with experiments for the control of the codling moth on

pears. Owing to a lower mean temperature in this valley than in many other fruit-growing regions, the period for the life cycle of the codling moth was greatly lengthened, requiring from sixty to seventy days, as compared with forty-nine to fifty-six, the time required in the East. Spraying experiments for the codling moth in the Ignacio Valley on pears were completed and gave very satisfactory results. Plats of trees receiving two and three applications of arsenate of lead in Bordeaux mixture gave, respectively, 87.68 per cent and 97.10 per cent of sound fruit, whereas on the unsprayed fruit trees only 46.85 per cent of the fruit was free from injury. There was a net gain in favor of spraying of \$1.49 per tree. A detailed report on the life history of the insect in the valley and the results of the experiments on pears has been submitted for publication.

Demonstration spraying for the codling moth is being continued during the season of 1910, as heretofore, in cooperation with the Bureau of Plant Industry, mostly in connection with other investigations at the several field laboratories. This work is in progress on pears in several localities in California and on apples in Michigan and Virginia and in nine counties in eastern Kansas in cooperation with the Kansas State Agricultural College. A detailed life-history study of the insect is also being made in the Santa Clara Valley. The demonstration spraying under way in Virginia, Arkansas, Pennsylvania, and Michigan during 1909 was successfully completed and gave uniformly good results. This work has been most heartily appreciated by orchardists in the respective neighborhoods and seems worthy of further extension.

THE GRAPE ROOT-WORM.

The investigations of the grape root-worm, which have been in progress since 1907, were continued over the growing season of 1909 as outlined in the report for that year. This investigation has been very thorough both in the field and in the laboratory, and entirely practical and economical measures have been fully demonstrated. The work was therefore practically concluded in the fall of 1909 and a full report has been submitted for publication.

MISCELLANEOUS GRAPE INSECTS.

In the course of the work on the grape root-worm much information was accumulated on other grape insects. It was found that some of these were of considerable importance, and upon the closing of the grape root-worm studies specific attention has been directed to the so-called rose bug and the grape leafhopper in the Erie grape belt. Studies are also being made on a new insect enemy of the grape, namely the grape bud gnat, which is assuming more and more importance as an enemy of this crop.

ARSENIC ACCUMULATION IN SOILS IN SPRAYED WOODLANDS, ORCHARDS, AND VINEYARDS.

The agitation concerning the danger of injury to orchard, shade, and other trees by excessive spraying with arsenicals, especially with arsenate of lead, led to an examination of soils in sprayed orchards, woodlands, etc., to determine if there were possibly an accumulation

of arsenic in the soil, and an examination also of trees which might be injured from this cause. A large number of samples was collected during the summer of 1909, and these have been examined by the Bureau of Chemistry, in cooperation with which Bureau the work is being done. The examination of these soils has shown the necessity for further studies and an additional series of soil samples will be collected from the same territory as those earlier obtained.

INSECTICIDE INVESTIGATIONS.

Further experiments have been made with lime-sulphur washes, especially when used with various arsenicals. Special attention is being given to determine the effects of a combined lime-sulphur and arsenical spray on peach foliage, including the various brands of arsenate of lead and other poisons, such as arsenic sulphids, arsenate of iron, zinc arsenate, etc. In California much attention has been given to the preparation of various sprays, especially emulsions of crude oil and distillate, in the course of experiments against the European pear scale and the European fruit Lecanium, or, as it is better known, the brown apricot scale.

DEMONSTRATION SPRAYING FOR THE PLUM CURCULIO.

The plum curculio in the South is a veritable scourge to the peach growers, every year greatly curtailing the crop, its punctures in the fruit, moreover, forming a nidus for brown-rot spores, greatly favoring infection from this serious fruit disease. So critical had become the situation due to the losses from these two troubles—the curculio and the brown rot—that the assistance of the Department was asked through the Georgia Fruit Growers' Exchange, and also by numerous large commercial orchardists. In cooperation with the Bureau of Plant Industry, demonstration spraying on a large scale was begun in different parts of Georgia, using arsenate of lead and self-boiled lime-sulphur mixture as a combined treatment for the curculio and brown rot and the scab. The scheme of treatment requires three applications in all, which practice it had previously been determined would effect the control of the several troubles. In addition to the work under the direct supervision of the Department a very large number of orchardists, acting under its advice, has adopted the plan of spraying recommended, and the total trees treated during the spring of 1910 aggregated several hundred thousands. This work is conducted on a strictly commercial basis, careful account being kept of the cost of the work, and the benefits will be accurately determined by a comparison of the fruit on sprayed and unsprayed blocks.

CRANBERRY INSECT INVESTIGATIONS.

The studies of cranberry insects in Wisconsin, in cooperation with the university of that State, mentioned in earlier reports, were continued along the lines indicated during the season of 1909, and beginning with the spring of 1910 demonstration spraying has been inaugurated in cooperation with numerous cranberry growers, who bear all costs of the work except for spray materials. An unusually

complete survey of injurious insects of the cranberry bogs in Wisconsin has been about completed, and a good knowledge of the life history of most of these has been obtained. These studies have been made on the bogs under perfectly natural conditions and will be of the utmost value as a basis for making recommendations for their control. Spraying operations under way in 1909 were carried through the season and the results recorded in a way to show the benefits in dollars and cents. The general absence of the fruit-worm, which had been very destructive the year previous, however, resulted in less marked benefits than previously obtained; nevertheless, the results from spraying showed a considerable improvement over unsprayed plats. This work will be concluded at the close of the present season, and it is planned to extend it to cranberry bogs in other States.

CEREAL AND FORAGE-PLANT INSECT INVESTIGATIONS.

Several new problems have engaged the attention of the cereal and forage insect section of the Bureau, under the charge of Mr. F. M. Webster, and the older investigations have been continued.

THE SO-CALLED "GREEN BUG."

The spring grain-aphis, or so-called "green bug," has continued to claim attention. During the autumn of 1909 it seemed to have reached its usual abundance along the line extending from North Carolina to New Mexico, but the ensuing winter was normally cold and restrained the pest, while in March there was an extraordinarily high temperature which enabled the parasites to develop in the spring, so that the pest was soon overcome by its natural enemies. The reverse of this—that is to say, a warm winter and a cold spring—would have certainly produced an enormous abundance of the insect. This emphasizes more than ever the imperative necessity for continuing government surveillance over the region where this pest first begins its depredations in the spring. This area covers approximately 13 States and Territories, while the territory now known to be occupied by the species, and therefore more or less threatened, covers approximately the whole United States west of about the latitude of the city of Washington, excepting perhaps in extreme western New York and Pennsylvania. At present it seems possible to diagnose the situation by keeping close watch upon the species throughout the area where it first begins its ravages, and by utilizing the records of the Weather Bureau. The studies of the past year emphasize the statement previously made that an outbreak of this pest depends upon temperature conditions beginning in the South, and the extent of its ravages depends wholly upon weather conditions during winter and spring. It seems, therefore, extremely desirable that there should always be a sum available for this particular investigation.

A complete report on this insect and its parasites will be prepared for publication during the fiscal year 1911.

WORK ON THE JOINTWORM.

The investigation of the jointworm has been continued more particularly throughout Ohio, Indiana, and southern Illinois, but the insect has been found injurious for the first time in the wheat in Mis-

souri. Curiously enough, another problem has entered into the jointworm investigation, which involves sanitary as well as agricultural matters. A mite known as *Pediculoides ventricosus* attacks both the jointworm and its hymenopterous parasites, and by its work upon the parasites prevents them from overcoming the jointworm. The mite remains in the straw up to and during the early summer following the harvest, and, whether this straw goes into the manufacture of mattresses or whether it enters into the domestic economy of the farm, it invariably causes a very annoying skin disorder, recently designated by Doctor Goldberger as *Dermatitis schambergi*. Throughout the Middle West the jointworm is the host of this mite, but the mite has caused equally serious trouble in eastern Pennsylvania, New Jersey, Delaware, Maryland, and Tennessee. Throughout this last territory the host insect is the Angoumois grain moth. In both cases it appears that a revision of certain agricultural methods will become necessary. The farmer throughout the Middle West and in the East draws the unthrashed grain in from the fields, places it in barns, and allows it to remain unthrashed for weeks, and sometimes perhaps even for months. This facilitates the development and increase of the mite, and causes an increased number of cases of dermatitis. In Tennessee the farmers allow the grain to remain in the shock long after it should have been thrashed. This also facilitates the increase of the mite, with the result that when this grain is thrashed the men and teams engaged in the work are attacked and caused great pain and suffering. In all cases, if the wheat is thrashed directly from the field and as soon after harvest as it is in condition for thrashing much of the difficulty will be overcome.

HESSIAN FLY INVESTIGATIONS.

The investigations of the Hessian fly have been continued, and a successful introduction of parasites from Kansas has been made into the wheat section of western Oregon. It now seems quite possible as the result of the investigations of the year that what was supposed to be winter-killed wheat in Oregon has really been the work of the Hessian fly. In recent years farmers have found it impracticable to grow wheat in western Washington and Oregon on this account. The attacks of the Hessian fly in the fall have produced this result, and the successful introduction of eastern parasites should have a beneficial effect.

An unexpected outbreak of the Hessian fly in Tennessee is being investigated in cooperation with the agricultural experiment station of that State.

Up to the present time it has been impossible to secure absolute proof that the Hessian fly will attack grasses, but it has been ascertained during the year that it attacks one or more species of *Agropyron* both in Kansas and in western Washington. To what extent this phase of the problem will increase in the future it is impossible to predict, but it will have the effect of allowing parasites to breed in grass affected by the Hessian fly and to migrate to wheat fields and attack the host insect there.

THE NEW MEXICO RANGE CATERPILLAR.

The unusual and serious state of affairs caused in northeastern New Mexico by the sudden extraordinary development of the larva

of a large moth attacking the gramma grass on cattle ranges was referred to in the last report. An expert assistant devoted a large portion of the fiscal year to an investigation of this outbreak, and the results have been published in Part V of Bulletin 85 of the Bureau. The insect has spread from a limited area in northeastern New Mexico into the Panhandle region of Texas and the Cherokee strip of Oklahoma, as well as into adjacent portions of Kansas and Colorado. Owing to the immense territory covered by the insect, and to the topography of the country, some of which is almost inaccessible, applications usually employed for destroying insects are impracticable. Only a very small percentage of the caterpillars are parasitized, and yet, from the present outlook, the introduction of parasitic enemies seems the only remedy.

THE ALFALFA WEEVIL.

The alfalfa weevil, beginning in the region about Salt Lake City, is apparently an introduced European insect. It was first observed in the vicinity of Salt Lake, not far from nurseries importing more or less stock from southern Europe, thus indicating a possibility of its introduction in the packing of stock. At the end of the fiscal year 1910 it was making rapid headway toward the alfalfa fields of Colorado, Wyoming, and Idaho. It constitutes a great menace to alfalfa culture. Studies of the life history of the weevil have been carried on in cooperation with the Utah agricultural experiment station, and experimental work has been done with remedies. The peculiar life history of the insect, however, which lays its eggs during a period of six weeks in the spring, near the base of the plant, renders operations against the larvæ extremely onerous on account of the necessity of frequent repetition. An experiment was made in the introduction of a fungous disease which kills an allied weevil in the Atlantic States, but without success. Possibly in irrigated regions with the proper moisture conditions this disease may be made to take hold.

THE SORGHUM MIDGE.

The sorghum midge, which prevents the sorghum raisers in the far South from securing seed, has been thoroughly investigated, and the results have been published. It now seems as though a large part of the difficulty experienced will be eliminated by the destruction of trash left in the field and of the Johnson grass escaped from cultivation and growing along roadsides and other waste places.

OTHER INVESTIGATIONS.

The other investigations of this branch of the Bureau work have included a study of the wheat strawworm in Kansas and the extreme Northwest, the corn root-aphis, the cowpea curculio, the slender seed-corn ground-beetle, a butterfly larva damaging alfalfa in California, Arizona, and Nevada, a gall fly attacking the seed pods of alfalfa in Arizona, the southern corn leaf-beetle, the southern corn root-worm, wireworms, and a number of other species. An important investigation has also been carried out regarding the exact relations of leafhoppers to the cultivation of grains and grasses. It was shown some

years ago by Prof. Herbert Osborn, of the Ohio State University, that the productiveness of pastures is very greatly reduced by these insects, and it is hoped by this investigation to ascertain facts which will bring about amelioration.

WORK ON INSECTS AFFECTING VEGETABLE CROPS.

Work against insects affecting vegetable crops has been carried on, as during the last two years, in different parts of the country. The work has been both demonstrational and investigational. As pointed out in the report for 1908, although the insects occurring in these different regions are frequently identical, their habits and life histories differ on account of the difference in climate, and require either different remedies or modifications of the same remedy. The work has been carried on as heretofore under the direction of Dr. F. H. Chittenden. It is estimated that the annual loss in a number of the most important truck-growing regions of the country from insect damage is 20 per cent of the crop, and that the preventable injury is about 15 per cent, thus indicating the value of the most up-to-date knowledge in this direction.

INVESTIGATIONS IN TIDEWATER VIRGINIA.

Investigations reported upon in the last annual report, in cooperation with the Virginia truck experiment station, the Virginia department of agriculture and immigration, and with associations of truck growers of Norfolk, Va., and vicinity, have been continued. Much demonstration work was found necessary, but some important investigations have been carried on. It has been found that the pea aphid may be successfully controlled by spraying early in the season with whale-oil soap at the rate of 6 pounds to 50 gallons of water, three or four sprayings being necessary for the best results. Tests were made with different nicotine preparations against this same species. Experiments with a lime-sulphur-arsenate-of-lead mixture for the Colorado potato beetle were found quite effective, destroying fully 95 per cent of the insects by a single application. Experiments have been continued against the striped cucumber beetle, the best results being obtained with a combination of arsenate of lead, 3 pounds, in Bordeaux mixture, 2-5-50, as a spray. The strawberry leaf-roller has also been studied in this locality as well as certain other insects.

STRAWBERRY INSECT INVESTIGATIONS IN NORTH CAROLINA.

Beginning with March, 1910, an agent was stationed at Chadbourn, N. C., to study strawberry insects. In 1908 the strawberry weevil caused the destruction of 50 per cent of the strawberry crop in one locality in North Carolina, the cash loss being \$700,000. In 1909 the loss in the immediate vicinity of Chadbourn was estimated at \$150,000. Especial attention was given to the life history of the species in the locality mentioned. As a result of the preliminary study which has been given to this species and the tests of remedies thus far, it is the belief that the following four items of farm management will work well in keeping strawberry fields free from weevil attack:

1. Cultivation of a large acreage.

2. The destruction by burning of all adjacent undergrowth in the late fall or winter, and the removal of all wild food plants and debris in which the insects could find winter quarters.

3. High cultivation to secure a maximum number of buds.

4. Immediate and close cultivation of the beds after picking, to destroy infested buds.

The strawberry leaf-roller and a root-worm were also studied in this locality.

INVESTIGATIONS IN COLORADO.

At the beginning of the fiscal year work on truck-crop insects in Colorado was begun, with headquarters at Rocky Ford. The investigation was taken up in cooperation with the Rocky Ford Chamber of Commerce and the commissioners of Otero County and the Rocky Ford Melon Growers' Association. Work was continued until December 1, 1909, and resumed March 11, and continued to the end of the fiscal year 1910. A preliminary test was made of the trap-crop ladybird method of controlling the melon aphid, early growing crucifers being used as a trap crop. The species was largely controlled by natural enemies, so that slight damage was done.

The yellow bear caterpillar did much damage to sugar beets and to the truck crops of the upper Arkansas Valley. It was decided that the best method of controlling the pest was the cleaning up and burning of the rubbish in fence corners and similar places where the insect hibernates. In the same way the best remedy for the larger beet leaf-beetle, or "alkali bug," was found to consist in destroying heaps of weeds, tufts of grass, and other debris in which the insect passes the winter.

The red spider in its occurrence on celery, beans, and other plants, including shrubs, ornamental bushes, and trees, was readily controlled by the use of a lye-sulphur solution.

Further studies were made of other crop insects in this region.

TRUCK INSECTS IN MISSISSIPPI.

In the summer and fall of 1909 work was begun in the State of Mississippi against truck insects, with headquarters at Starkville. This work is still going on against the pests especially injurious to cabbage, Lima beans, melons, tomatoes, and strawberries.

IN CALIFORNIA.

An especial investigation of insects damaging sugar beets and truck crops has been carried on in this State with headquarters at Compton, and the life histories of the insects concerned have been studied and experimental work instituted.

IN SOUTHERN TEXAS.

The work at Brownsville, mentioned in previous reports, has been continued. The onion thrips, with the melon aphid, appears to be the most serious truck-crop pest of southern Texas, and as to the onion thrips the work so far done indicates that unless remedial measures, such as the changing of the farming methods or the appli-

cation of poisonous sprays, are undertaken, the cultivation of this important crop must be abandoned. The practice of growing onions by starting them in sets seems to be one of the chief causes of injury by thrips. Some injury may be prevented by dipping sets, before transplanting, in nicotine sulphate at about the same strength as used in spraying. Clean methods of cultivation, including prompt destruction of remnants, and the stimulation of plants by means of fertilizers and irrigation where possible, are among the best forms of farm procedure. In some localities the observance of these methods serves to hold the insect in check; in others it is also necessary to spray.

Reports upon a number of Texas insects belonging to this class have been submitted and accounts will be published.

OTHER INVESTIGATIONS ON TRUCK-CROP INSECTS.

The onion thrips just mentioned is by no means confined to Texas, but occurs also in Colorado, and recent reports of injury have been received from Stark County, Ind. The estimate of loss in the latter locality was \$30,000 for 1910 in the vicinity of the town of Knox alone. The same insect also occurs in the vicinity of the District of Columbia, and studies of its habits in this locality have been begun.

WORK ON INSECTS AFFECTING CITRUS FRUITS.

As during the previous year, the work on insects affecting citrus fruits has been carried on under the supervision of Mr. C. L. Marlatt. The principal items have been the continuation of the white-fly investigations, work upon the orange thrips in California, and the completion of the hydrocyanic-acid gas fumigation in California.

WORK ON THE WHITE FLY IN FLORIDA.

With the conclusion of the main features of the life-history studies and fumigation experiments on the white fly, summarized in previous reports, problems connected with insecticides and the mechanics of spraying as adapted to Florida conditions have been made the subject of especial study. The agents of the Bureau, however, have continued the very important experiments leading to natural control by bacteria and fungi, and have cooperated with growers in conducting fumigation on a large scale.

Experimental work and observations during previous years with parasitic fungi have demonstrated that under normal climatic and favorable grove conditions the fungi are capable of effecting in a series of years about one-third of a complete remedy, and that they can be very readily introduced artificially into groves infested with the white fly. The main line of investigation during the past year has been to determine to what extent the natural efficiency can be increased by frequent artificial introductions of spores by spraying at stated periods throughout the summer and early fall. This work has not given encouraging results. The amount of fungus present at the end of the season in no instance was enough greater than that developing under normal conditions in unsprayed surrounding trees to warrant from a practical standpoint the time expended in the

work. In several instances more fungus developed on unsprayed trees. Observations and experiments have led to the conclusion that losses resulting from the white fly attacks will be greatly reduced if, in the majority of cases, the parasitic fungi are disregarded and the use of direct remedial measures extended as fast as possible.

While no specific bacterial disease of the citrus white fly or spotted-wing white fly has yet been discovered, it became evident very early in the present investigation that mortality among larvæ and pupæ resulting from causes other than those recognized as attacks by insect and known fungus enemies, and from overcrowding, was the most important element of natural control affecting these species. This heretofore unappreciated check effected by nature has been credited to the fungi, greatly enhancing the value of the latter. In several instances the fungi have been credited with controlling the fly in groves in which none of the known fungi was present, or in which they were present in too small numbers to bring about the great reduction in the numbers of flies. This phase of natural control is still under investigation.

Fumigation experiments were conducted only in cooperation with the Tangerine Citrus Association of Tangerine and the growers of Arcadia. In each instance an agent of the Bureau gave assistance in securing the necessary apparatus and chemicals and in the general methods of procedure. The fumigation of over one thousand trees under varying conditions thoroughly demonstrated the value of the method of control in isolated groves, as well as its uselessness in groves closely surrounded by untreated infested groves.

The experimental work of the previous year to determine the cost and effect of various insecticides has been continued, together with an extensive study of the mechanics of spraying as adapted to the peculiar conditions presented by the problem in hand. It has been found that by a careful application of knowledge gained by life-history studies the cost of insecticides can be reduced about two-thirds during late spray; while experiments have shown that their cost can be safely reduced about one-half during the summer months, due to the greater susceptibility of the larvæ and pupæ at this season. The control of the fly by spraying has been undertaken in several groves, consisting of several thousands of trees of all sizes, and data are accumulating to warrant the statement that spraying, when once given an intelligent continued trial, will be found a much more promising method of control than is generally believed.

THE ORANGE THIRPS.

The orange thrips, a serious insect enemy of orange in the southern San Joaquin Valley in California, has been under investigation for about two years, and most gratifying progress has been made in the determination of control measures. Large-scale experiments with various sprays have been continued, and on the whole the pest has proved to be less resistant to the sprays than was found to be true of its near relative, the pear thrips. Two or three applications, however, appear to be necessary, since there is a series of generations occurring during the year. The actual area of orange groves under experiment by the Bureau in 1910 is approximately 30 acres, the growers cooperating in allowing the use of the trees. The destructiveness of

the insect and the successful results obtained by sprays have resulted in a very active interest on the part of orchardists themselves, and a large number of power sprayers have been purchased and extensive spraying operations begun under the advice and immediate supervision of agents of the Bureau. The total area of orange groves treated for the orange thrips during the spring of 1910 is approximately 2,000 acres. This is the more remarkable when it is remembered that previous to the spring of 1909 practically no spraying whatever was practiced.

INVESTIGATION OF HYDROCYANIC-ACID GAS FUMIGATION IN CALIFORNIA.

The investigation of hydrocyanic-acid gas fumigation in California, taken up at the beginning of the fiscal year ending June 30, 1908, was completed with the close of the fiscal year ending June 30, 1910. The same character of field work has been continued throughout, and efforts were made to conduct the investigation on as nearly a commercial scale as possible, so that conditions and results would be those normal to the ordinary care of citrus groves. The results, which have been brought together in the form of a bulletin about to be published, have been very satisfactory. The orange growers expressed themselves as pleased, and the expense of the operation has been very considerably reduced, and, as a result of the efficiency obtained, longer intervals between fumigations will now serve to keep the groves in good condition. Important experiments have been conducted with sodium cyanide, and it has been found that with the use of a high-grade sodium cyanide the results are as satisfactory as with a high-grade potassium cyanide. When it is considered that the present manufacture of sodium cyanide is more universal and greatly in excess of potassium cyanide; that the sodium compounds required in the manufacture of sodium cyanide are widely distributed throughout the world, while commercial deposits of potassium compounds required in the manufacture of potassium cyanide are largely confined to the German Empire, and also that the present unit price of sodium cyanide averages slightly less than that of the other, it may reasonably be expected that in the future the sodium may be found supplanting potassium in American usage.

The field laboratory at Whittier, Cal., used in these investigations, was abandoned June 30, when the lease expired, and the apparatus was turned over to the Bureau. The agent in charge, Mr. R. S. Woglum, was transferred to another investigation.

INVESTIGATIONS OF INSECTS IN THEIR DIRECT RELATION TO THE HEALTH OF MAN AND DOMESTIC ANIMALS.

One of the most interesting investigations under the branch of the Bureau work dealing with insects in their direct relation to the health of man and domestic animals has already been mentioned in this report in the earlier section on "Work on the jointworm." As the jointworm is a host of the mite in question, it is considered in full in that section rather than here.

The subject of remedies and preventive measures for mosquitoes has been considered at great length in a bulletin published in the spring of 1910 (No. 88), and the whole ground has been rather thor-

oughly covered. It is hoped to follow this bulletin on the active remedial work with others treating of malaria and the malarial mosquitoes, of yellow fever and the yellow-fever mosquito, of the general habits of mosquitoes, and still another on the classification of mosquitoes.

THE HOUSE FLY.

The work on the house fly has been continued, and the crusade against this disease-bearing species has been assisted in every possible way. The name, suggested by the writer, of "typhoid fly" as a substitute for the name "house fly" is becoming generally adopted. Conservative physicians appear to be more and more convinced of the dangerous qualities of this insect. The American Civic Association has taken up the crusade, and boards of health and citizens' improvement societies all over the United States are paying great attention to the destruction of this species. The crusade has extended into other countries, and the Bureau congratulates itself on having at last aroused strong public opinion in a very important sanitary matter.

WORK ON TICKS.

The work of the Bureau on the important injurious ticks of the country has been conducted under the direction of Mr. W. D. Hunter by Mr. F. C. Bishopp. These investigations have consisted of two primary lines of work: First, with the tick which transmits splenic fever of cattle, and, second, with the species *Dermacentor venustus*, which transmits spotted fever of human beings in some of the Rocky Mountain States.

The work on the cattle tick consisted of two parts, one dealing with the continuation of life-history studies and the other with practical demonstrations of methods of control for the benefit of ranchmen. The great diversity of climatic and other conditions in the area infested by the cattle tick causes it to be exceedingly important to ascertain the local variation in the development and life history of the pest. Moreover, such definite information must be available for the practical work of eradication which has been undertaken by the Bureau of Animal Industry and can only be obtained by means of experiments running through several years. Consequently, the experiments to determine the length of time the seed ticks can survive without hosts were continued. Special efforts were made to secure records from a number of localities. In this work the Tennessee experiment station cooperated in a very helpful manner.

On account of the general popular idea that sulphur taken into the system of cattle either by feeding or drinking of water impregnated with the substance will cause the ticks to drop off, a special experiment was arranged to furnish exact information. A fence was built around a well in southern Texas, the water from which is very heavily impregnated with sulphur. Small droves of cattle heavily infested with ticks were placed in this inclosure from time to time and observations were made regarding the action of the ticks. The results were entirely negative. The well used in the experiment represents extreme conditions as regards sulphur content. The results, therefore, are of very definite value and should prevent the useless expenditure of money for sulphur on the part of cattle owners.

Two large demonstration pastures in southern Texas, one in Victoria County and one in Calhoun County, were utilized for the purpose of demonstrating the feasibility of reducing the tick infestation to a practically negligible quantity. Cattle were removed from these pastures in the spring and returned in the fall. It was found in both pastures that the cattle were practically free from ticks in the spring, although the cattle which had been pastured elsewhere were heavily infested. In the demonstration pastures a continuous and very profitable gain in weight was made and in the others the cattle were in such condition from tick infestation that very low prices were secured.

Efforts to cause the parasite of the brown dog tick to attack the cattle tick were continued but without definite results, except as to methods of manipulation that will assist in future work. Shipments of the parasites were made to South Africa and Italy for attempted introduction by the government entomologists.

Progress was made in the work on the species of ticks which transmit spotted fever of human beings. An agent traveled through some of the Northwestern States to obtain material to reveal the distribution of the species. This work will result in an exact knowledge of the geography of the disease, or at least the region in which it can spread if once introduced. Following this preliminary work, a camp laboratory was established in the Bitter Root Valley, in Montana, where a very virulent phase of the disease exists. Through this laboratory a study was made of the distribution of the dangerous ticks in the locality. There are many points that need investigation. For instance, the disease occurs commonly on the west side of the valley but rarely on the east side. This phenomenon is probably due to some limitation in the distribution of the ticks. In addition, studies of the life history, habits, and means of control will be conducted and demonstrations will be inaugurated if the investigational work seems to warrant it. This work is in cooperation with the Montana State University and the Montana board of health. Prof. R. A. Cooley, of the university, has become a collaborator of the Bureau, and is directing the work. On account of his extensive study of the problem it is considered that the Bureau is fortunate in being able to perfect this arrangement. One of Professor Cooley's students is stationed at the camp. The Biological Survey of the Department is also cooperating. It has stationed two men in the field to determine the limitations in the range of the various animals which act as hosts for the ticks. The Montana board of health has agreed to place a physician at the camp. The work is therefore organized in a comprehensive way and should yield important results.

In addition to the work in the Bitter Root Valley a large amount of information concerning the distribution of the ticks throughout the Rocky Mountains region was obtained by means of circulars. In this way over 500 lots of ticks were obtained, representing practically as many localities. This will enable the Bureau to map the distribution of the form which is now known to be pathogenic in nature and of others which may later be found to be capable of transmitting diseases.

In addition to the main lines of work indicated, progress has been made in the study of some of the other important ticks. A number

of experiments with the fowl tick have been conducted. This form is so injurious that it has caused the abandonment of the poultry industry in some places. The work has been carried far enough to result in practical suggestions for control which will be dealt with in a circular soon to be issued.

There is a possibility that destructive ticks may be introduced into this country from Mexico at any time. They might be brought across the boundary on cattle, horses, dogs, or even human beings. In order to determine the actual danger an agent was sent through northern Mexico for a few weeks during the year. The results indicate that precautions against the entrance of new forms should by all means be taken.

WORK ON INSECTS INJURIOUS TO STORED PRODUCTS.

The work on insects injurious to stored products has been continued along similar lines, under the direction of Dr. F. H. Chittenden. Special attention was given to inspection and fumigation, as demonstration work and as experiment, in mills in Kansas, Texas, Oklahoma, Missouri, and Louisiana.

THE POINT OF INFESTATION TO EXPORT FLOUR.

The original source of the trouble which caused requests for this line of investigation was the infestation, chiefly by flour beetles (*Tribolium ferrugineum* and others), of export flour milled in the States mentioned and shipped to Europe and Africa, mainly through the ports of New Orleans and Galveston. During the two years in which this topic has been under constant investigation, in the warmer months which permit of such work, effort has been made to determine the exact point of infestation, which might be at any place—at the mill or between that point and the place where the flour is delivered to the purchaser. While a possibility exists of infestation on car and steamship lines, on wagons used in carting the flour or other cereal from the mills to the port of destination, and at the ports both in this country and abroad, it is now established that in the vast majority of cases the point of primary infestation is the milling establishments themselves. A large number of mills have been investigated in the States mentioned, and while many are maintained in a scrupulously neat and clean manner and are fumigated twice a year, or as often as necessary, still there are many others where carelessness prevails and where fumigation is not regularly performed. In the carelessly kept mills, flour beetles, the Mediterranean flour moth, and various other mill pests accumulate and are carried from the mills on sacks of flour, thus infesting cargoes which reach foreign ports in unsalable condition. Under conditions favorable to their development, in warm weather, some of the insects can develop from egg to adult in five or six weeks.

THE MEDITERRANEAN FLOUR MOTH.

As in the past year, the Mediterranean flour moth has again engaged the largest share of attention. The larva or caterpillar of this species is the greatest pest with which millers have ever had to con-

tend. It particularly infests the machinery of mills, spinning a web which causes flour to become felted and lumpy, and, in summer weather, this clogs the machinery, necessitating frequent and prolonged "shut-downs" resulting in the loss, in large establishments, of thousands of dollars. The average cash loss due to closing a mill and the cost of treatment by fumigation and cleaning has been estimated at about \$500 for each fumigation, excluding the loss to business, while the owners of mills of large capacity who have fumigated for this species claim a loss of \$5,000 a year. One prominent miller states that the loss due to stoppage while cleaning is incalculable.

The use of hydrocyanic-acid gas as a means of disinfecting mills, warehouses, elevators, and other inclosures has become nearly universal in the principal milling centers, and especially as a remedy for the flour moth. It possesses many advantages over bisulphid of carbon for the same purpose, the principal ones being that the gas can be generated without the aid of fire as in sulphur fumigation, and that it is noninflammable and nonexplosive when generated according to methods now in practice. Hence its employment in mills where there might otherwise be a conflict with insurance companies.

On account of numerous inquiries during the year (which reached as high as five or six daily at times) for advice in regard to the eradication of the flour moth, it was found necessary, as soon as the required data could be obtained, to publish a comprehensive account of the hydrocyanic-acid gas method of fumigation for the control of this pest. This is published as Circular No. 112 (pp. 1-22). In order to make this publication as complete as possible all of the principal topics which were discussed during the year on this process of fumigation were considered in detail, with the result that to date no questions have been asked since its issuance that are not completely answered in the publication.

RICE MILL INVESTIGATIONS.

By request of several rice millers, some mills in southern Texas and Louisiana were investigated. In the course of these investigations, as well as in others conducted both in the Mississippi Valley region and in the Atlantic district, it has been noticed that hydrocyanic-acid gas has one serious defect, and this has been brought out especially during the year. It has very limited penetrative power when used in fumigating sacks of grain and rice. When used under ordinary diffusion, the fact that the greater portion of both clean and weevily rice is stored in sacks under ventilated sheds or in loosely constructed buildings makes the problem of fumigation entirely different from that of the flour mill or grain elevator. If it could be possible to apply hydrocyanic-acid gas and bisulphid of carbon with pressure, as is used in sulphur fumigation by the Clayton process, this problem might be solved. Otherwise it is probable that under existing conditions we will have to depend upon heat as a remedy. Experiments are being conducted in this direction.

MISCELLANEOUS INVESTIGATIONS.

The export docks of Baltimore, Philadelphia, and New York have been visited and investigations have been made of the local condi-

tions and the insects present in both import and export flour and other cereals.

Fumigation of mills, grain storehouses, and bakeries have been conducted in the city of Washington with good success and will be continued as opportunity offers, the work extending into some nearby mills in Virginia.

More inquiries were received in regard to methods for the prevention of weevils in corn and other stored cereals in the South than in several years, and much information was given in regard to this topic. Efforts were made to ascertain to what extent cereals, especially corn, are attacked in the field, and it was found that in many cases field attack is the direct result of storing grain in the immediate vicinity of grain fields or of planting near granaries. Some common practices in the Gulf region, such as "pulling" or "snapping" fodder so as to expose corn ears to the ripening and hardening effects of the sun, tend to increase injury by the Angoumois grain moth and the rice weevil and should be discontinued. Early harvesting, prompt threshing, and storage in bulk all conduce largely to the prevention of infestation. For the rest, cleanliness in the depositories, with fumigation, preferably before storage, will destroy the insects which remain.

A branch of this topic which will sooner or later demand attention is as to the effect of "weeviled" grain to stock and to human beings when taken as food. Practically nothing definite has been done in this line, although it has been known for some time that horses are badly affected by "weeviled" grain and by the "dust," chiefly excrement, occurring in infested oats and other cereals. They also refuse to eat food containing large granary insects, such as the meal-worms. Chickens, swine, and cows do not appear to be badly affected by a moderate amount of this material, but doubtless all would suffer from a larger diet of "weeviled" grain.

In all, the principal seaboard mills and terminal elevators exporting grain and other cereal products from the Atlantic coast have been inspected and the insects infesting export and import cereals have been studied. In addition, various blending plants and factories manufacturing cereal products, and storage depositories, have been kept under constant observation.

The use of bisulphid of carbon, while prohibited by fire-insurance underwriters in many cases, is still in use for other insects than the flour moth, which affect stored products, and in some cases its use is practically necessary; for example, for spraying spouts and other portions of machinery where hydrocyanic-acid gas is unable to penetrate a large mass of flour. It is also used to a considerable extent either before or after hydrocyanic-acid-gas fumigation.

Experiments have been made with sulphur fumigation where it was not practicable to use other means of treatment, and these have been found successful.

During the year upward of 100 reports were received from many of the principal milling establishments of the country giving results of the treatment of the mills by hydrocyanic-acid gas fumigation.

An agent of the Bureau, working chiefly in the States of Kansas and Texas during the year, has submitted more exhaustive reports

on experiments with all of the different methods of fumigation which have been mentioned.

In cooperation with the Bureau of Chemistry, insects injurious to imported dried fruits, and especially Smyrna figs, have been studied. Means for their control have been formulated and the work will be continued.

INSPECTION WORK.

As in previous years, all seeds and plants introduced and distributed by the Division of Foreign Seed and Plant Introduction of the Bureau of Plant Industry, as well as ornamental plants imported by florists in the District of Columbia, have been thoroughly examined. In addition to these, about 2,000 cherry trees, a gift from the city of Tokyo to the Government of the United States, were examined and found to be infested with a number of injurious insects. All of these plants were destroyed. Several insects were collected on plants introduced by the Bureau of Plant Industry, which, if allowed to gain a foothold in Florida or other warm portion of the country, might prove serious enemies to cultivated crops.

In addition to this work carried on at Washington, a somewhat elaborate inspection system for products proceeding from regions in New England inhabited by the gipsy moth and the brown-tail moth has been conducted by the gipsy moth force as indicated in a preceding paragraph.

INSPECTION FOR THE IMPORTED BROWN-TAIL MOTH NESTS.

In the last report the efforts of the Bureau to prevent the importation of brown-tail moth nests upon seedlings shipped from Europe to nurserymen in the United States were described. The extraordinary numbers in which these nests were found upon this imported stock was due probably to the occurrence of the brown-tail moth in certain parts of Europe in most unusual numbers during the summer of 1908. In the summer of 1909 the same conditions existed, and as a result the shipments of nursery stock from portions of Europe in the autumn of 1909 and the winter of 1909-10 again carried many nests. Moreover, upon one shipment of nursery stock from Belgium to Louisiana an egg cluster of the gipsy moth was found. By an especial arrangement, through the kindness of the Secretary of the Treasury, with the custom-houses, and by agreement with the railroads, the Bureau was notified of all cases of plants received, and, as in the previous autumn and winter, secured the inspection of probably every shipment at the point of ultimate destination. Shipments of nursery stock to the number of 291 were found to be infested with nests of the brown-tail moth, and these went to the States of Colorado, Connecticut, Georgia, Illinois, Indiana, Kansas, Louisiana, Michigan, Montana, New Jersey, New York, Ohio, and Virginia. In most of the States inspection was rendered simple by the fact that there were efficient state inspection laws and official inspectors. Notification in such cases from the Bureau was all that was necessary. In other cases where there was no such state service, the inspection was carried on either by employees of the Bureau or by expert collaborators appointed for the purpose.

THE NECESSITY FOR A NATIONAL QUARANTINE AND INSPECTION LAW.

As pointed out in the last annual report, the United States is practically the only one of the great nations of the world which has not protected itself by law from such accidental importations of pests of this character. During the winter an inspection law, based upon the permit system, was drafted and submitted to Congress after consultation with the legislative committee of the National Nurserymen's Association. Thorough hearings on the bill were held before the Committee on Agriculture of the House, but, probably owing to a disagreement on certain sections between the Nurserymen's Association and the officials of the Bureau, the act was not placed upon the calendar.

The hope is again expressed that a satisfactory bill may be drafted the coming autumn, and that it will receive the sanction of both houses of Congress.

In June, 1910, the Chief of the Bureau visited Holland, France, Belgium, and England, in order to look once more into the conditions of growing nursery stock and into the inspection systems in those countries as well. The French Chamber of Deputies failed to pass the inspection law proposed by the ministry of agriculture during the past season, owing to some doubt as to the question of expense. The director of agriculture of France, however, is certain that arrangements will be made in the very near future for the establishment of the competent service referred to in the last report. In the meantime, however, Belgium has established a service, under the directorship of Doctor Staes, of Ghent, which promises efficient inspection in the future. The officials of the board of agriculture in London state that the exporters of nursery stock in Great Britain are willing to have an inspection service started, and it seems probable that the English Government will move in this direction.

The insect conditions in the regions of the large exporting nurseries of France, in the vicinity of Angers, Orleans, and Ussey, were found to be very favorable during June, 1910. For some unknown reason it was with the utmost difficulty that a lepidopterous larva of any kind could be found in the north of France—not a single brown-tail moth caterpillar or gipsy moth caterpillar could be found in any of these nursery regions. The mayor of Angers, during the winter of 1909–10, put in force the hitherto neglected police measures providing for the destruction of every visible nest of the brown-tail moth during the hibernating season. It is quite possible that the efficiency with which this work was carried out has contributed to the clean condition of the Angers nurseries the present season. It seems impossible that the condition of nursery seedlings imported from France during the coming winter can be at all like those of the two past winters, but governmental and state vigilance should not be relaxed on this account, since there are many other European insect pests which constitute dangers to the United States aside from the brown-tail moth and the gipsy moth.

WORK IN BEE CULTURE.

The work in bee culture has been carried on as before under the direction of Dr. E. F. Phillips.

WORK ON BEE DISEASES.

The work of the past fiscal year on bee diseases has demonstrated more clearly than before that this is the most important subject before the bee keepers of the country. The study of the bacteria of the two infectious bee diseases has been continued, with especial attention to the amount of heat and chemical disinfection necessary to destroy the causative organisms. The results are of great value in prescribing methods of disinfecting contaminated material. The drug treatments advocated by European writers have been carefully tested, and it has been found that none of the drugs is of any value in treating American foul brood, even aggravating the condition in some cases. A large amount of work has been done in the effort to establish the cause of European foul brood. Repeated efforts to produce the disease by giving colonies of bees the organisms supposed to be the cause, namely *Bacillus alvei* and *Streptococcus apis*, have been uniformly unsuccessful. The results of the work so far carried on show only that the disease can be transmitted by feeding infected material. Other organisms found in diseased individuals are being studied, and new media are being tried. The disease responds to the treatment recommended for American foul brood, but, until the cause is ascertained, little can be done further on the remedial side.

In the last report it was stated that the effort to learn the distribution of bee diseases in the country would be completed by the close of 1909, but it has been found that these diseases are much more widespread than was supposed, and it will take at least one more summer to make the work complete enough for record. Samples of dead brood suspected of disease have been obtained from all parts of the United States, and during the past fiscal year 620 samples were examined, as against 280 the previous year. The data obtained in this study of distribution are utilized mainly in sending a practical circular on the treatment of brood diseases to all the bee keepers in infected districts whose names can be obtained. Every effort is made to inform the bee keepers in the infested territory how to combat the maladies. This information is also available for use by bee keepers who are applying for the passage of state laws for the inspection of apiaries, since it indicates the need of such legislation.

It has been found that the treatment recommended by the Bureau can be carried out successfully, not only with no financial loss, but often with an actual increase in returns if done in time.

STUDIES OF THE STRUCTURE AND DEVELOPMENT OF THE BEE.

Work on the structure and development of the bee, which was announced in the last annual report, was completed during the year in so far as the anatomy of the bee is concerned, and the results were published in a technical bulletin. A large number of errors of former observers have been corrected in this bulletin. Accurate information concerning bee anatomy is necessary in many lines of apicultural investigation, especially in investigating the physiology and behavior of bees, these lines being of importance in practical manipulation.

Work on the development of the egg stage of the bee has been conducted during the past year.

WORK ON THE BEHAVIOR OF BEES.

Investigations have been carried on during the year as to the means by which bees find their way to flowers, the source and gathering of propolis, the behavior of bees on unprotected combs, and color vision. These studies of behavior under normal and abnormal circumstances are highly important in devising practical manipulations.

EXPERIMENTS WITH BEESWAX.

During the past year some preliminary experiments on the removal of the beeswax usually left in slumgum were conducted. It was found that there is usually a considerable amount of wax lost in the methods of wax extraction now employed, and an effort is being made to make an apparatus which will remove this wax economically. The extraction of all the wax from combs is most important, since, where disease is concerned, there are many combs to be rendered. Complete extraction would add greatly to the profits of large apiaries. Bee keepers in various parts of the country are cooperating with the Bureau in the collection of samples of beeswax produced during the gathering of different kinds of honey, since it is known that beeswax from different sources varies considerably in its physical properties.

MISCELLANEOUS.

An effort has been made to learn what is being done in this country and abroad in regard to education in bee culture.

A new location for the Bureau apiary has been obtained at Chevy Chase, Md., and the number of colonies is being increased to accommodate the needs of experimental work.

UNCLASSIFIED WORK.

As in previous years, a great deal of work has been done in different directions which can not be classified under the main sections.

Especial attention has been paid, as in previous years, to the study of pecan insects, especially in Texas and in Mississippi. In the same way the insects injurious to ornamental plants have received considerable attention throughout the year.

More work has been done than in recent years on the subject of insects injurious to shade trees. The demand for information in regard to insects of this class is constantly increasing. Circular publications have been issued on some of the more important species, but new forms appear occasionally, and insects hitherto considered of no economic importance occasionally develop in enormous numbers and destroy the shade trees in certain cities. During the past year the European leopard moth has done serious damage to the shade trees of Cambridge, Mass., and vicinity, and a new pest from Europe, the elm scolytus, has made its appearance in the vicinity of Boston. So serious has been the damage of these two imported pests and of the imported elm leaf-beetle that the beautiful elm trees of Cambridge have been dying by hundreds. In June, 1910, 1,000 large trees were removed. The Bureau has endeavored to aid in all such cases by giving advice, and where investigations can be made of

the insects of this class at Washington or at the field laboratories of the Bureau they are carried on incidentally to other work.

The work of the specialists of the Bureau, to which annual reference has been made, in the determination of specimens sent in by state entomologists and other workers in practical entomology has again increased. The interest in the study of insects from the practical point of view has grown enormously in recent years, and Washington, by virtue of its large libraries and large force of entomologists, has become the center for this determination work, which could hardly be done as well elsewhere. Much time is occupied in this work, but not only can this hardly be avoided, but it has a very important bearing upon the practical work of the state entomologists, the teachers of economic entomology, and others engaged in practical work. During the fiscal year more than 26,000 specimens were examined in this way.

The correspondence of the Bureau continues to increase, and, in addition to correspondence by circulars, more than 22,500 letters have been written.

The publications of the Bureau have increased in number, fifty-three new publications having been issued during the fiscal year.

PROPOSED WORK FOR THE FISCAL YEAR 1911.

With the gipsy moth and the brown-tail moth work for the fiscal year 1911, some changes in methods are being considered. Continued effort will be made to reduce the cost of the methods in use along woodland roads, and continued experimentation will be made in the hope of finding some means of caring for woodland regions. An improvement in the method of inspecting products shipped by the railroads from infested regions will be made, and a larger force of permanent inspectors will be established from among the more intelligent of the men at present on the rolls.

With the importation of the parasites of the gipsy moth and the brown-tail moth, the time has arrived to reduce the large bulk of the importations, and in the future to bring over only those species which have not yet been received in sufficient abundance to establish perfect colonies. At the time of this writing an agent is in Europe studying the best methods of bringing this about, and is looking into the question of the autumn life and probable methods of hibernation of some of the species involved. More time will be spent upon the study of the species already introduced, in order to secure a more accurate idea than we have at present of what is to be expected of them in the next few years.

With the cotton boll weevil, investigations along the same lines reported upon for the year 1910 will be continued. The work in the Mississippi Valley continues to be the most important work, but it may be necessary during the coming winter and spring to establish observation stations farther east, on account of the continued eastern spread. Experimental field work, however, will be continued throughout the whole infested area. The work upon tobacco insects, sugar cane insects, and rice insects will be continued as outlined in this report, as well as the studies of the cotton red spider and the cotton root louse in South Carolina and adjoining States.

With forest insects, the investigations of the past fiscal year will be continued. The demonstration work outlined in this report will be carried on as vigorously as the cooperation of the Forest Service and of private owners will permit.

With deciduous fruit insects, the investigations already outlined will be continued to the close of the season, at which time some of them will be concluded. It will be desirable to continue the work with the pear thrips, although the scope of the operations may be lessened. Further codling moth studies are desirable, especially in the Southeast, as in Georgia, which is a coming apple State, and in the Southwest, as in New Mexico and California. Plum curculio demonstration work will probably be continued and enlarged. A study of fruit-insect parasites is to be begun. The establishment of a laboratory in the New England States for the study of the apple maggot and other fruit pests, which was found impracticable in the spring of 1910, it is hoped may be effected in the spring of 1911.

With cereal and forage-plant insect investigations there will be no great expansion of the investigations, but as much attention as possible will be paid to the *Hemileuca* caterpillar damaging stock ranges in New Mexico, and to the alfalfa weevil in Utah.

No new work, except in a small way, will be carried on in insects affecting vegetable crops.

With insects affecting citrus fruits, as already pointed out, the investigation with hydrocyanic-acid gas has been completed; the work upon the orange thrips will be continued, and the work on the white fly will be carried on in about the same way as during the past fiscal year. Congress has made an appropriation of \$5,000 for the investigation in this and foreign countries to discover natural enemies of the white fly, and, in consequence, an expert agent has been sent to oriental regions, where there is reason to believe that the white fly has its original home, in a search for these natural enemies. This mission will probably occupy the greater part of the fiscal year.

Under the work on insects in their direct relation to the health of man and domestic animals, a new series of investigations has been begun on house fly conditions in relation to the agency of this pest in the spread of typhoid fever and other intestinal diseases. Experimental work with mosquitoes will be carried on in a small way. The investigations of the southern cattle tick are being continued. Much important work on the spotted fever tick is under way, having been begun shortly before the close of the last fiscal year. The presence of spotted fever—which is transmitted in nature only by the tick—interferes with the development of large areas of land in the Northwest. The camp laboratory in the Bitter Root Valley will be continued during a portion of the season, and efforts will be made toward obtaining exact information regarding the distribution of the dangerous ticks throughout the territory in which spotted fever occurs. It is hoped that the information gained will enable the residents of the Bitter Root Valley to undertake a campaign of eradication.

The work on insects injurious to stored products will be carried on along the same lines, the only innovation being the sending of an expert assistant to Smyrna to study the conditions under which Smyrna figs become wormy, in the effort to bring about conditions which will enable importers to bring in and sell wormless figs, meeting the provisions of the pure food law.

Inspection work will be continued as thoroughly as possible in the absence of a national law, and in the same manner in which it was carried on during the past year.

In apiculture the work in progress will not be completed for several years, and the same investigations, therefore, will be continued.

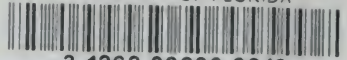
PLANS FOR WORK RECOMMENDED FOR THE YEAR ENDING JUNE 30, 1912.

It is hoped that it will have appeared from this report and the ones preceding that the Bureau is accomplishing good practical results, and that naturally its opportunities should be increased. The writer has no hesitation, therefore, in view of plans in sight, in asking for an increase to the lump fund appropriation of \$54,750. It is proposed to expend \$36,000 of this increase in adding to the funds devoted to the investigation of insects injurious to forests. The practical results of this work as displayed in this and the other reports have been noticeable. Until the past year or two the small allotment devoted to this work was sufficient to meet the requirements of the field work, which has been directed toward the determination of the principal insect depredations and practical methods of control. This, however, has been accomplished, and it is desired to render greater service in practical results in demonstration work on a large scale. More experts should be employed, and sufficient means should be given the service to enable it to do its part in the prompt and effective manner required to command the confidence and support that is so essential in securing the effective cooperation of the other branches of the Government service and of private timber owners. Ten thousand dollars of the increase asked for will be devoted to the important problem of the alfalfa weevil, concerning which some information is given in this report. This money should be spent in cooperation with the state authorities of Utah and the other States which will be involved in all probability before the beginning of the fiscal year 1912. With the remainder of the increase recommended, it is proposed to devote \$3,000 to the investigation of southern field crops, especially sugar cane and rice, in addition to the sums already allotted to that purpose; to give \$3,750 to further increase the facilities of investigations of insects injurious to truck crops, and \$2,000 increase to the investigations being carried on against bee diseases.

It is also respectfully urged that the salary of the Chief of the Bureau be increased to \$5,000. The importance and scope of the work connected with the Bureau seem such as to justify this increase.



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